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SIR WILLIAM FAIRBAIRN.

IF extensive usefulness be the measure of true greatness, Sir William Fairbairn was a great man. Few have accomplished so much in such a quiet unobtrusive way, and if we consider the difficulties he met and overcame in life, few have been more thoroughly successful. He was no mere favourite of fortune. He relied not upon his ancestry, or his lucky star. His faith was firm in persevering effort, even in the midst of discouragement, and thus he won the smiles of fortune by his patient endeavour and his resolute determination to do his work, whatever it might be, faithfully and well. Other men have made more brilliant discoveries in science, but few more useful ones, and in coming years his name may be linked with those of Newton, Davy and Watt, as one of the representative inventors of his time.

Sir William Fairbairn was born at Kelso, in Roxburgshire, Scotland, February 19, 1789. His father, Andrew, was a man of industrious and frugal habits, blessed with a large family,

but endowed with slender resources. His mother, whose maiden name was Margaret Henderson, traced her descent from the ancient border family of Douglas, and certainly possessed all the Douglas energy of character. William received his first schooling from an old Cameronian who went by the name of "Bowed Johnnie Ker." It was a peculiarity of this old man's instruction to teach his pupils to *sing* their reading lessons, and to imitate a strong nasal twang with which he was naturally gifted. After this, young Fairbairn was sent to the parish school, where he gained some knowledge of arithmetic, and learned to read from a book containing selections of prose and poetry. He was now ten years of age, and amused himself rather with boyish sports than with the mysteries of reading, writing, and arithmetic. The ruins of Kelso Abbey developed his taste for archæology, and it was his especial delight to explore them. When he was in his twelfth year his father was offered the charge of a farm of 300 acres near Dingwall in Ross-shire, and to this remote district the whole family removed in October 1799. The journey of 200 miles was accomplished in a covered cart, but on arriving at their destination they were much disappointed to find the land covered with bushes and rocks, and no place for a home save a miserable hovel. However they submitted to their hardships and privations with a good grace, and after two years of labour they were rewarded with abundant crops of barley, oats, and turnips. Their house was completed, and the family, consisting of Mr. Fairbairn, his wife, and five children, lived in comparative comfort. But it was a struggle for life on this rugged farm. During this time the boys were employed in helping their father, for they could not be spared to go to school. The energy of Mrs. Fairbairn was indefatigable. She not only attended to her ordinary duties, but span and made all the blankets and sheeting for her household, all the clothes for her children, and even her husband's coats. Such industry was more common in those days; but even then she was looked upon as a pattern among a people proverbially thrifty, and her generosity and goodness of heart were equally remarkable.

"The child is father of the man," and William Fairbairn even at this age displayed great ingenuity in making numerous windmills, water-wheels, miniature boats and ships. His parents noticed the bent of his mind and encouraged him in these efforts. Peter Fairbairn was a delicate child two years old, and William, with an old saw, a knife, and a gimlet for tools, set himself to the task of constructing a waggon in which to wheel about his little brother. The wheels were a puzzle at first, but were finally made from cross-sections of an alder tree with the holes for the axles bored with a red-hot poker, and in this car, which answered admirably, the future Sir Peter Fairbairn, mayor of Leeds, was trundled.

In the year 1801 the whole family removed to Allengrange. William was sent to school and made progress in elementary studies. He laid a good foundation at this time for the self-training which was his main reliance in after-life, and when he became a man, it was his custom to say to those who complained of wanting early advantages, that one might have many worse teachers than oneself. After two years at Allengrange, Mr. Andrew Fairbairn, with the idea of bettering his condition, determined upon another removal. He sold all his household goods, and in June, 1803, the family sailed from Cromarty to Leith, proceeding from thence to Kelso, their old residence, where they remained with friends, while the father accepted a situation as manager of Sir William Ingleby's farm at Ripley. William Fairbairn was now fourteen years old, and the exigences of the family required his services. He obtained his first work on the fine bridge at Kelso, in process of erection from the designs of John Rennie, the famous engineer. He met with an accident here while attempting to wheel a load of stones too heavy for him, and badly injured one of his legs, so that he was laid up several months. His father meanwhile had secured a position as manager of the farm belonging to the Percy Main Colliery Company, near Newcastle-on-Tyne, and before the end of 1803 William found employment at the colliery, his first labour there being to convey coals from behind the screen to the pitmen's houses. The collier boys and men with whom he associated ridiculed the Scotch accent, and perhaps the awkward appearance, of the lad, and he was often challenged to fight with them. It is said that he fought no less than seventeen pitched battles with these rough companions, when they learned to respect his courage and valour, and left him thereafter unmolested. At the age of sixteen he was articled as an engine-wright apprentice for five years at Percy Main Colliery (one of the largest in that vicinity), with wages of eight shillings per week; but by working overtime he contrived to add still further to the general fund of the family. His evenings were sedulously devoted to study, and he drew up a plan, for the sake of system, as follows: Monday, mensuration and arithmetic; Tuesday, history and poetry; Wednesday, recreation, novels and romances; Thursday, algebra and mathematics; Friday, Euclid and trigonometry; Saturday, general recreation; and Sunday, church-going, Milton, &c. He had the resolution to carry out this programme, and also a thirst for knowledge which made it more to him than a mere plan on paper, to be forgotten in a week. One of his achievements at this time was the construction of a fiddle; but nature evidently had not designed him for a musician, for he gave up practice upon it after a while, much to the relief of the ears of the family. He excelled in everything he ever undertook with the exception of music. Many years after, while engaged in erecting some machinery for Messrs. Gros, Deval, and Co., at their cotton-mills in Alsace, at an entertainment given by M. Gros, Mr. Fairbairn, in conversation, was describing the process of making home-brewed ale. His host was a fine performer on the violin, and after delighting the company with some excellent music, he handed the instrument to Mr. Fairbairn, asking him if he could play. "A little," was the half-unthinking reply. All present insisted with much clamour that Mr. Fairbairn should favour them. He then gave them one of his best tunes, "The Keel Row." "By gar," said his host, "that be home-brewed music."

Our young engineer was in due time promoted to take charge of the steam-engine, and the pumps of the colliery, and this, although it entailed exposure, was an occupation more to his taste. Many a time was he drenched to the skin, as he descended the shaft to look after the pumps, but thanks to a strong constitution he endured all hardships without injury. It was about this time that he made the acquaintance of George Stephenson, who was then working the ballast engine at Willington Quay, Newcastle-on-Tyne. He himself says he "was very fond of George, who was a fine, hearty fellow, besides being a capital workman;" and that many a fine summer evening he used to go down and relieve George of the care of his engine, while he took the opportunity to earn a few shillings by shovelling out ballast from the collier vessels for a few hours. The elder Mr. Stephenson used to look back to those days with pride, and, referring to his labours with the shovel, would remark that young men now did not know what work was. The eminence that awaited these men was foreshadowed by their devotion to earnest labour of hand and brain.

His apprenticeship completed, at the age of twenty-one, with robust health and a stalwart frame, Mr. Fairbairn determined to go out into the world as a journeyman, in the strict sense of the word, in quest of experience, only to be obtained by travelling and finding work in different places. For a short time he found employment at Newcastle, and afterwards for six months at Bedlington.

Work was not easily found in the north and Fairbairn determined to go to London. On the 11th of December, 1811, he took passage in the cabin of a collier sailing from Shields, with a fellow-workman who had joined him in his fortunes. The crew were representatives of youth and age—three old men and three boys, besides a bibulous captain and a mate. War and the press-gang had carried off the sailors, and there were not men enough aboard to work the vessel, so Fairbairn and his friend were invited to bear a hand. The sea was very rough, and the drunken skipper nearly wrecked his ship off Yarmouth by keeping too near shore.

After a perilous voyage of fourteen days they arrived in the Thames with loss of spars and an anchor. The captain went ashore to find the Coal Exchange, taking Mr. Fairbairn with him, but owing to the lingering effect of his frequent potations, he was unable to get farther than a public-house in Wapping. At ten o'clock at night they started to return to the vessel, when the captain took advantage of his companion's ignorance of the locality, and slipped away from him, only to spend the night himself in the watch-house, where he was found crest-fallen in the morning. Mr. Fairbairn, alone and unknown in a strange city, inquired for a suitable lodging, and was directed by a watchman to a house in New Gravel Lane. The next morning he was horrified to hear that a whole family (the Williamsons) had been murdered during the night in the next house. He rejoined his friend on the ship as soon as possible, and they went together to look for work, first to Mr. Rennie, who received the young men kindly, and requested his foreman to give them employment. The foreman referred them to the secretary of the Millwrights' Society. Mr. Fairbairn alluded to this experience in one of his addresses delivered many years later: "When I first entered London," said he, "a young man from the country had no chance whatever of success, in consequence of the trade guilds and unions. I had no difficulty in finding employment, but before I could begin work I had to run the gauntlet of the trade societies, and after dancing attendance for nearly three weeks, with very little money in my pocket, and having to 'box Harry' all the time, I was ultimately declared illegitimate, and sent adrift to seek my fortunes elsewhere. Laws of a most arbitrary

character were enforced, and the unions were governed by cliques of self-appointed officers, who never failed to take care of their own interests." They therefore found, after repeated trials, that the London trade unions, formed to keep up the standard of high wages rather than to protect trade, presented insuperable obstacles to their obtaining work in the metropolis, and they determined to try what they could find in the country. Accordingly they set out early one morning in the snow and rain to walk to Hertford. Their funds were nearly gone, and they were obliged to content themselves on the way with a penny roll and a pint of beer. After a tedious tramp of eight hours they arrived, forlorn, wet, and hungry. The millwright to whom they applied had no work for them, but offered Fairbairn half-a-crown, which he declined, much to the regret of his companion, who was ready to despair. As they were near Hertford churchyard, they strolled in to deliberate what should be their next attempt. "Come, come," said Fairbairn to his disheartened friend, who declared he would "na gang a bit farther," and wanted to return to London—"it's no use crying; we must try another road; something will soon cast up—if the worst comes to the worst, we can enlist." The next day at Cheshunt, seven miles farther, they found work on a windmill, and remained a fortnight, when they returned to London with a capital of nearly £3. It was not long before Mr. Fairbairn obtained work in London, first at Grundy's Patent Ropery in Shadwell, and afterwards at Penn's Engineering Works at Greenwich.

Again there were dull times in London, and the young millwright, more than ever confident in himself, and in his own practical knowledge and experience, resumed his travels. He went through the West of England to Bristol, and thence through South Wales to Cardiff.

Finding little work, he made the voyage to Dublin, where he arrived with only three halfpence. However, he was not discouraged, for he was a skilled workman, and he readily found employment with Mr. Robinson of the Phœnix Foundry, where he devoted himself for the summer to the task of making some improved nail machinery. When the work was completed, he crossed over to Liverpool, and as Manchester was rising rapidly in importance as a great manufacturing town, he resolved to settle there. Mr. Adam Parkinson first employed him for two years, and in 1816, at the age of 29, after his marriage to Miss Dorothy Marr of Morpeth, whose acquaintance he had made while at Bedlington, he began to have the ambition to establish a business of his own. A prize was offered for a bridge over the Irwell at Manchester, and he presented designs for a handsome cast-iron structure, which were not accepted, as a stone bridge was preferred. Next he was engaged in preparing plans for an iron conservatory. One of his shopmates, Mr. James Lillie, helped him in this work, and this was the origin of their partnership, which lasted many years. They began in a small way by renting a shed for 12*s.* a week. Here they set up a lathe of their own construction, while a strong Irishman took the place of a steam engine to turn it. This humble shop did not attract very large orders, and Mr. Lillie was sometimes ready to despair. His partner, however, was more hopeful, and went about among the leading manufacturers, showing the designs of his cast-iron bridge, and requesting their patronage. Messrs. Adam and George Murray, the prominent cotton-spinners, were Scotchmen, who had thriven in Manchester, and in time he called upon them soliciting orders. Mr. Adam Murray conducted him through their mill, where the gearing and shafting were of that heavy description in general use at that time, and it occurred to Mr. Fairbairn that a vast improvement might be made by substituting light wrought-iron shafts, revolving rapidly, for the heavy cast-iron ones upon which turned the large slowly-revolving wooden drums, making only some forty revolutions per minute. These and other defects in the machinery he proposed to rectify, and Mr. Murray, after calling at their shop to satisfy himself that they could undertake the task, gave them the order. By working early and late they completed the contract in the specified time, and, what was better, the new machinery gave perfect satisfaction. The weight and cost were diminished, and the power increased more than fourfold. The enterprising young firm next fitted up the cotton-spinning mills of McConnell and Kennedy with the improved machinery, and their work was highly praised. Their success gave them such a reputation among the mill owners that they found it impossible to meet the flood of orders. They were forced to extend their works, and finally erected a large manufactory fitted with every necessary appliance. The circular half-flap coupling was one of their greatest improvements. The spinning trade rapidly assumed an importance which it has never lost, and no small share of its growth in Manchester and many other places at home and abroad is due to the inventive brain of William Fairbairn.

From this time Mr. Fairbairn moved upon the tide-wave of prosperity. His labours were unremitting, and every new success seemed only to stimulate him to greater activity. After a series of interesting experiments on the use of iron as a material for ships, he made in 1831 an iron vessel—one of the first ever constructed—which was carried from his works in Manchester, and launched. In 1835, he opened an extensive shipyard (afterwards occupied by Mr. Scott Russell, in whose yard the Great Eastern was built) at Millwall, London, and during fourteen years he constructed more than 120 iron ships, some of them above 2,000 tons burthen. He was one of the great pioneers in iron-ship building—now one of the principal industries of Great Britain, and he went on making new discoveries and inventions, among others the machine for riveting boilers and iron plates, obviating the slow and expensive hand process of hammering the red-hot rivets.

While making so many experiments with iron, he tried its value as a material for building purposes. In his lecture on the "Progress of Engineering" he says, "I am one of those who have great faith in iron walls and iron beams. It is now twenty years since I constructed an iron house with the machinery of a corn mill for Halil Pasha, then Seraskier of the Turkish army at Constantinople. I believe it was the first iron house built in this country, and it was constructed at the works at Millwall in 1839."

We come now to the history of one of the greatest triumphs of Sir W. Fairbairn's life, and which must for ever associate his name with that of Robert Stephenson, without detracting from the merit due to that great engineer. The vast and increasing traffic across the Menai Straits, rendered it very important to the Chester and Holyhead Railway Company to find some safe and expeditious way of crossing this arm of the sea and also the broad estuary of the Conway. About a mile below the Britannia rock the straits were spanned by Telford's fine suspension bridge, and it was at first proposed that the railway should take one side of this bridge, but the insecurity of such structures for the passage of heavy trains had been proven, and the idea was abandoned. Many had sought to solve the difficulty. Mr. Rennie, in 1801, had prepared the plans for a cast-iron bridge at the Swilly rocks, and Mr. Telford, in 1810, proposed one with a single cast-iron arch of 500 ft. Mr. Robert Stephenson's favourite site was at the Britannia rock, which rose in the middle of the strait, and for this he planned a large iron bridge having two cast-iron arches, each arch of 450 ft. span, with a height of 100 ft. at the crown of each arch—the total cost to be £250,000. But all these schemes were rejected by the Admiralty. Large vessels were continually going up and down the straits, and not to impede navigation a clear headway of 105 ft. was required at the piers, as well as at the centre of the arches. Moreover such wide arches had never been attempted before, and the changes of the atmosphere, and the vibration caused by the passage of heavy goods trains, were to be considered. Met by these obstacles, Mr. Stephenson conceived the idea of a great tubular bridge, supported by chains as "auxiliaries." He had erected a bridge some years previous for the North Eastern Railway Company somewhat similar, and it had proved a success. He objected at first to the rectangular form on account of the large surface presented to the wind. Circular or elliptical tubes seemed best to him, which, like hollow beams of iron, hung on chains, should be firm and rigid by their immense weight. Mr. Robert Stephenson gives the following account of Mr. Fairbairn's first connection with the enterprise. "My late revered father having always taken a deep interest in the various proposals which had been considered for carrying a railway across the Menai Straits, requested me to explain fully to him the views which led me to suggest the use of a tube, and also the nature of the calculations I had made in reference to it. It was during this personal conference that Mr. William Fairbairn accidentally called upon me, to whom I also explained the principles of the structure I had proposed. He at once acquiesced in their truth, and expressed confidence in the feasibility of my project, giving me at the same time some facts relative to the remarkable strength of iron steamships, and invited me to his works at Millwall to examine the construction of an iron steamship which was then in progress." This meeting occurred early in April, 1845. Mr. Fairbairn says that "on that occasion Mr. Stephenson asked whether such a design was practicable, and whether I could accomplish it, and it was ultimately arranged that the subject should be investigated experimentally, to determine not only the value of Mr. Stephenson's original conception (of a circular or elliptical wrought-iron tube supported by chains) but that of any other tubular form of bridge which might present itself in the prosecution of my researches. The matter was placed unreservedly in my hands, the entire conduct of the investigation was entrusted to me, and as an experimenter I was to be left free to exercise my own discretion in the investigation of whatever forms or conditions of the structure might appear to me best calculated to secure a safe passage across the straits."

On the 30th of June, 1845, the bill for the construction of the bridge received the royal signature, and the directors of the company voted £6,000 for experiments soon after. These were entered upon by Mr. Fairbairn, first with sheet-iron tubes about eighteen inches in diameter. The initial experiment was made July 6, 1845, with the cylindrical form. It was found that the cylindrical tubes, like miniature bridges, resting on supports at either end with the weight suspended from the centre, failed generally by compression, or doubling up of the top. They were also with difficulty retained in form. The vertical diameter increased in length in the middle, and decreased at the ends. The elliptical tubes also yielded to a crushing force even after a cellular fin or compartment had been riveted along the top. The elliptical form was found to be less strong than the rectangular. In almost every case the top side was the weakest, and the ductile wrought iron yielded to compression, rather than gave way to the tension on the lower side. The important deduction from all these experiments was, that a tube submitted to transverse strain requires to be made stronger at the top than at the bottom, to obtain the greatest strength. In a letter to Mr. Stephenson, dated Sept. 20, 1845, Mr. Fairbairn writes: "It is more than probable that the bridge in its full size will take something of the following sectional shape." He then makes a sectional drawing, almost precisely like a section of the bridge as it stands to-day, which he describes thus: "The parts *a a* (the horizontal parallel plates at the top) being two longitudinal plates divided by vertical plates so as to form squares calculated to resist the crushing strain in the first instance, and the lower parts *b b* (horizontal plates at bottom) also longitudinal plates well connected with riveted joints to resist the tensile strain in the second." He says in one of his works on the subject: "From this period I date the disappearance of almost every form of difficulty respecting the construction and ultimate formation of the Britannia and Conway tubes. In these experiments, the ratio between the areas of the top and bottom sides was nearly as 5 : 3, and although subsequent trials upon larger scales with better proportioned and more perfect cells gave improved results, these experiments were nevertheless highly satisfactory, and supplied sufficient data on which to proceed with some degree of certainty in preparing the designs and drawings for the larger tubes. The powerful resistance offered to compression by the cellular form of top, at once decided in my mind the form to be adopted for the large tubes, and from this time forward I had no doubt as to the practicability and complete success of the undertaking."

A corrugated top, riveted together in two cells, was found very satisfactory in respect to strength, but all the cylindrical and elliptical tubes were easily distorted and bent out of shape. A section of this corrugated top resembled the bows of a pair of spectacles, and, after an experiment made October 14th with this form, which was the nearest approach in experiments of that scale to the cellular form finally adopted, Mr. Fairbairn said, that if the tube had been already constructed he could not have seen his way more clearly, and that his only regret was that Mr. Stephenson did not entertain the same degree of confidence, and Mr. Stephenson repeatedly declared that Mr. Fairbairn's "unlimited confidence and determined powers of resistance to those who condemned the proceedings, tended, almost more than anything else, to build the bridge."

Mr. Stephenson still clung to his idea of supporting the tubes by chains, indeed, he never for a moment entertained the theory of making the bridge self-supporting. He thought that some way should be devised for attaching the chains, and, in his report to the company, he cautiously left the matter in doubt.

Mr. Hodgkinson reported in favour of auxiliary chains, otherwise he thought great thickness of metal would be required to produce adequate stiffness and strength. Mr. Fairbairn in his report said significantly of the tube: "It should be a huge sheet-iron hollow girder, and provided the parts are well proportioned, and the plates properly riveted, you may strip off the chains, and leave it as a useful monument of the enterprise and energy of the age in which it was constructed." It will also remain an enduring monument of Sir William Fairbairn's genius and perseverance.

This advice was finally taken. The huge tubes were constructed, first for the Conway bridge, and, that there might be no possible failure, thoroughly tested. The result of this gigantic experiment on the first Conway tube is thus given. Rectangular tube 412 ft. long, 25 ft. 6 in. deep in the middle, 15 ft. wide, and 400 ft. between supports; area of top 670 in., area of bottom 517 in.; computed weight of tube 1,300 tons. The weight of the tube gave a deflection of nearly 8 in., for which allowance had been made, and 95 tons left in the inside of the tube for four hours increased the deflection from 9·02 to 9·25=23 in. This weight was continued for seventeen hours, with an increase of deflection of 10 in. After this 301 tons were laid on, when the experiment was discontinued. With 301 tons the deflection was 10·95. The length of the tubes for the Britannia bridge was 460 ft.

It has been well said, that if the bridge had proved a failure, Mr. Fairbairn would have had his share of the responsibility and odium, and perhaps the largest share. The world knows how the immense tubes were floated obliquely, swung round, and then raised by hydraulic engines of great strength; and how they have stood every test of traffic, storm and wind, for more than twenty years.

It would require a volume to give a complete account of Sir William's inventions and experiments during the last half century. He made great improvements in water-wheels, which have been universally adopted. He studied the density and force of steam, and discovered the law according to which it varies with different temperatures and pressures. He experimented on the tenacity of boiler plates, and the strength of various materials, and it was one of the most important of all his scientific discoveries, that the resistance of hollow cylinders to collapse from external pressure becomes less as their length increases. By the use of stiffening rings, dividing boilers into short lengths, as he suggested, many explosions have been prevented.

To the last Sir William Fairbairn manifested the deepest interest in the studies which had employed his life. Some very important experiments upon the strength of cylindrical boilers are now being made by the Manchester Steam Users' Association, of which Sir William was the late president, and the last letter that Sir William addressed to the association was on the subject of these tests, urging no delay, and fully approving of them.

He was a member of the committee appointed by the Government to make experiments at Shoeburyness on defensive iron plates, at the time when armour-plated war vessels were threatening to supersede the wooden walls of England.

The "Philosophical Transactions," "The Transactions of the Literary and Philosophical Society of Manchester," and the reports of the British Association, have contained many of Sir William's writings on these and other scientific subjects. He wrote the treatise on *Iron* in the "Encyclopædia Britannica," and the following is a list of his most important works, many of them published in book form:—

"Mills and Millwork;" "Canal Steam Navigation;" "Iron, its History and Manufacture;" "The Application of Iron to Building Purposes;" "Iron Ship Building;" "The Strength and other Properties of Hot and Cold Blast Iron;" "The Strength of Locomotive Boilers;" "The Iron of Great Britain;" "The Strength of Iron Plates and Riveted Joints;" "The Strength of Hollow Globes and Cylinders exposed to Pressure from without;" "The Cohesive Strength of Different Qualities of Iron and Stone;" "The Strength of Iron at Different Temperatures: Useful Information to Engineers" (three series).

He also contributed papers to scientific journals on such subjects as the following:—"The Economy of Raising Water from Coal Mines;" "The Consumption of Fuel and the Prevention of Smoke;" "The Comparative Temperature of the Climates of England and some parts of Italy;" "The Temperature of the Earth's Crust;" "Experiments to Determine the Efficiency of Continuous and Self-acting Brakes for Railway Trains."

After the death of Mr. Lillie, which took place many years since, Mr. Fairbairn carried on his great business in Manchester alone. About ten years ago it was transferred to the Fairbairn Engineering Company, Limited, of which his son, Sir Thomas Fairbairn, his successor to the baronetcy, is chairman. Sir Thomas is noted for his devotion to art, and has done much to encourage art studies in England. Sir William's only daughter was married in 1841 to Mr. John F. Bateman, a distinguished engineer, and it was while on a visit to his son-in-law that death claimed him, at the ripe old age of 85. He died at Moor Park, Farnham, Surrey, August 18, 1874.

Many learned societies, at home and abroad, have conferred their honours upon Sir William Fairbairn. In 1860, when the Queen's Medal of the Royal Society was awarded him, it was said, "Perhaps there is scarcely an individual living, who has made so many and so careful experimental inquiries on subjects of primary importance to the commercial and manufacturing interests of the country, and who has so liberally contributed them to the world." He was one of the founders of the British Association for the Advancement of Science, and its President in 1861, at which time he declined the honour of knighthood, wishing to remain plain William Fairbairn. He was, however, induced in 1869 to accept a baronetcy, conferred by the Queen for his valuable services to the country. He was a Fellow of the Royal Society, and a Fellow of the Royal Academy at Turin, a corresponding member of the Imperial Institute of France, a Chevalier of the Legion of Hon-

our, a member of the Institution of Civil Engineers, of the Institution of Mechanical Engineers, and many other scientific bodies. The Manchester Literary and Philosophical Society gave him the chair of the celebrated John Dalton. The honorary degree of LL.D. was conferred upon him by the Universities of Cambridge and of Edinburgh, and he bore all these distinguished honours with the greatest modesty.

Sir William Fairbairn was beloved for his qualities of heart, no less than respected for his intellect. When he delivered his presidential address at Manchester before the British Association, the present Lord Derby moved a vote of thanks, and said: "We all hear Mr. Fairbairn with respect, not only on account of the private character of the man—and he is known to all—but also because he himself is entitled to take an honourable place among the pioneers of scientific research;" and Mr. Aspinwall Turner, M.P., seconded the resolution, relating the following incident: "I cannot help saying that highly distinguished as William Fairbairn is amongst us, he is valued even more for his private character than for his scientific attainments. In a note I received from him some time ago, there is one expression most characteristic of the man. I addressed him as Dr. Fairbairn, and I believe I put some letters after his name. He replied, 'Pray in future address me as an old Dissenting minister named me many years ago—William Fairbairn.'"

He was always kind and considerate towards those in his employ and anxious to do them good. In the words of his son, Sir Thomas Fairbairn, in reply to a letter of condolence from the Manchester Mechanics' Institution, "A mechanic himself, Sir William was in the largest and truest sense the friend of mechanics. He was a co-operator with Dr. Birkbeck in the foundation of mechanics' institutions. His whole life was a noble example to working men. He hoped that it might be so. He worked for good unremittingly, unselfishly, and he accepted the honour, wealth, and reputation which were abundantly bestowed upon him, not in any boastful spirit, but as the rewards of honest labour. His works were labours of love, and I fervently pray that these and his pure, simple, kindly nature will keep his memory green in the hearts and affections of all who knew him."

The career of the late Sir William Fairbairn illustrates in a remarkable manner the power of self-culture and self-reliance. His mental training was not derived from the schools, but gained by patient toil unaided save by the light of his own genius and the strength of his indomitable will. From the smallest beginnings he rose to the greatest eminence in his profession, and his practical contributions to mechanical science will endure as his most lasting memorial. His patience and skill in solving the problems of nature were only equalled by his generosity in giving the fruits of his labour to the world, and after a long life replete with usefulness he has left a name inseparably connected with some of the greatest triumphs of modern engineering.

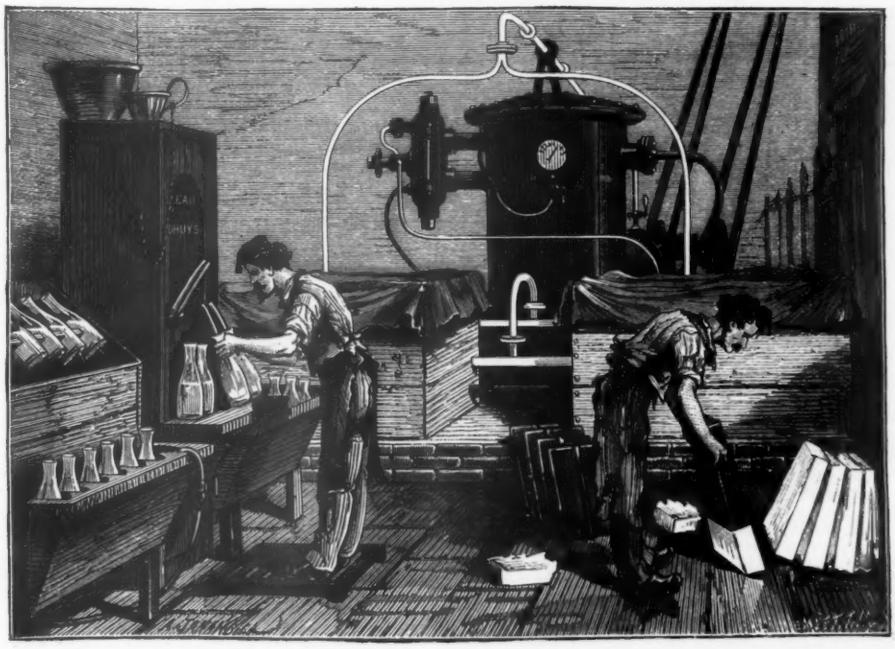


Fig. 5.

MR. CHARLES TELLIER'S COLD-PRODUCING APPARATUS.

IT is a well-known principle of physics, that when bodies undergo a change of form or condition, heat is required in order to effect this change: thus, when a liquid affects the gaseous form, or in other words, evaporates, it abstracts from surrounding substances the heat neccessary for that evaporation, and by so doing lowers their temperature, or cools them. We are all familiar with the effects produced by surrounding a bottle filled with water with wet clothes or straw, and exposing it to the air; the moisture is transformed into vapour, or evaporates, and in order to do so, it abstracts heat from the bottle and the water within it, and thus cools it. The same effect is perceptible to a greater degree by letting a few drops of sulphuric ether fall upon the hand; the ether in evaporating abstracts heat from the hand, and a very sensible sensation of cold is immediately experienced.

This principle is the basis of Mr. Tellier's invention; but he had to seek for a substance which would produce a much greater degree of cold than sulphuric ether, one capable of lowering the temperature even to congelation. This substance he found in methylic ether, which enters into ebullition at from 20° to 25° below zero Fahrenheit, whereas sulphuric ether boils at + 90° F., a difference of about 115°.

But methylic ether, although well known to the chemist in the laboratory, had hitherto never been prepared in such quantities as to permit of its being used for industrial purposes, and it was necessary to devise an apparatus specially adapted to that effect.

Methylic ether, like sulphuric ether, is the result of the action of sulphuric acid upon alcohol. Vinous alcohol gives sulphuric ether, but ligneous alcohol, or that which is distilled from wood, gives methylic ether. Sulphuric acid is mixed with ligneous alcohol in equal proportions, and heated until the ether is given

out, carrying with it a certain quantity of accessory substances, such as carbonic acid, sulphurous acid, empyreumatic vapours, &c. In order to get rid of these substances, it is passed through certain liquids, by which they are absorbed or retained. Thus, by passing the impure vapours over potash, carbonic acid and sulphurous acid are retained by the alkali, and the vapour of water is at the same time mechanically carried away, and in this manner the ether is obtained pure.

This method is simple, and is the one usually employed in all distillations, both on a small and on a large scale.

The only change made is in the form and in the substance of which the apparatus is constructed.

Instead of employing glass, as in the laboratory, the apparatus consists of tubes and enormous receivers, D, F, G, made of cast-iron, which are heated by steam. But it would not have been an easy matter to cause a substance which boils at the low temperature of — 25° F. to flow through the necessary tubes, had not Mr. Tellier hit upon the expedient of bringing it back to the liquid state by pressure, and thus rendering it again capable of locomotion. The methylic ether, therefore, after being distilled and purified, is passed into a special pump A, where it is compressed, and then goes in a liquid state into certain cast-iron receivers at R (tested to a high pressure), fig. 1, from which it flows through the rest of the apparatus as easily as water; for the pressure of this gas is not excessive, and does not exceed four or five atmospheres upon the sides of the tubes, which, together with the receivers, are calculated to resist and are tested to a pressure of fifty atmospheres.

As soon as methylic ether could be obtained in sufficient quantities, the manufacture of cold became possible; but, in order to render it generally applicable to industrial purposes, a special machine was necessary. Such a one was planned and constructed, and is now in incessant operation in a hundred different places in North and South America, and is likely to become of immense value in the silk-growing districts of France, as soon as the breeders of silkworms shall have become alive to the great use of such an agent as cold for the safe preservation of the eggs of this useful and valuable insect.

Fig. 2 represents Mr. Charles Tellier's cold-producing apparatus. B is the vessel in which the methylic ether is concentrated. The ether, while changing into vapour, passes from this into another part of the machine (*n* C *f*), where it abstracts the

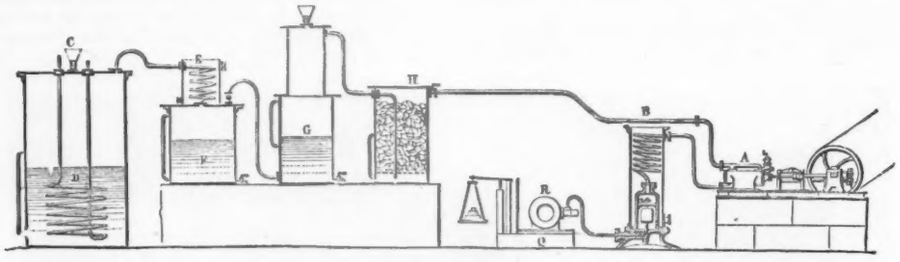


Fig. 1.

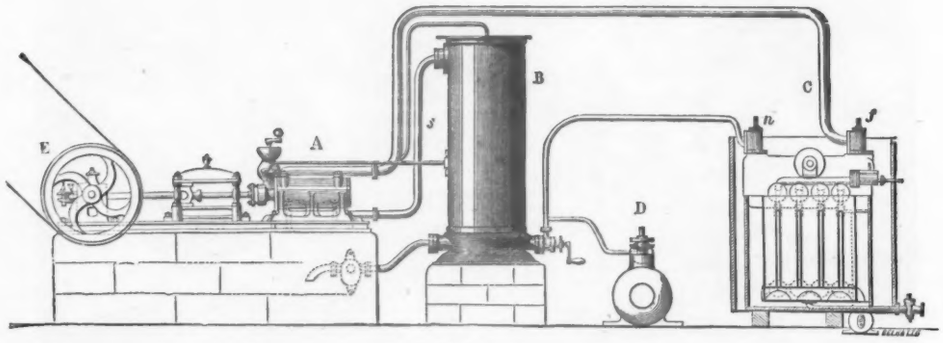


Fig. 2.

heat from the surrounding substances, or what amounts to the same, lowers their temperature. Therefore, whether it passes through tubes plunged into a solution of brine, or whether it is carried further on to reduce the temperature of air-tight chambers, the result will be the same; and by plunging forms of a proper shape filled with pure water into this brine, upon their being withdrawn they are found to contain beautiful slabs of clear ice. The methylic ether is now sucked up by the pump A, which is put in motion by a steam engine, the brake of which is seen at E: the ether undergoes compression and returns to the receiver at D, from which it is again liberated a second time as vapour, absorbing so much heat on its way that the tubes are constantly coated with hoar frost, and giving back that heat whilst undergoing the compression, which reduces it again to the liquid state, to such a degree that here, on the contrary, the tubes are nearly always red hot.

It is evident that a certain amount of pressure is developed in the worm B by the liquefaction of the ether. But in order that this pressure may take place it is necessary that the worm be closed; but if it is closed, how will the liquid, which is constantly being re-formed within it, be able to flow away? This is effected by means of the distributor, of which a vertical section is given in fig. 3. The most important part of the distributor is *d*, which turns upon the stock *a*. This stock is provided with two channels *u u* which join beneath. The liquefied ether is constantly coming in through the tube *f*, and fills the cavity *a*; but each time that the distributor in turning presents one of its cells *u* in front of one of the cavities of the stock, the cell becomes filled with liquid ether; and each time that it passes over one of the orifices *u u*, the ether is discharged through the lower tube owing to the pressure being less on account of those orifices communicating with the refrigerator.

A few words of description with reference to the *lubricator* (fig. 4) may not be uninteresting. This apparatus is destined to prevent, absolutely, any communication between the interior of the pump and the atmosphere, in fact to prevent the passage of the compressed vapours while permitting the action of the piston-rod. And so perfect are these appliances that no escape whatever is possible, a fact easily recognizable from the entire absence of any traces of the peculiar odour so characteristic of ether, and which would be immediately discernible were the slightest leakage to exist. The result is that the same quantity of ether is used over and over again without any loss. The lubricator consists of a spherical cavity cut in two, provided with a lower piston of which the lining is divided into two parts *f e*, separated by a ring *g*. In this manner the oil brought in through the tube *m* is constantly poured upon the ring *g*, and, consequently, upon the piston-rod, from which it prevents any

escape of vapours. Any such vapours which might have come from the compressing pump escape into the spherical cavity, passing through the layer of oil which partially fills it, and therefore cannot escape along the piston-rod.

Fig. 5 represents the general arrangement of Mr. Charles Tellier's cold-producing apparatus as it is set up at Auteuil.

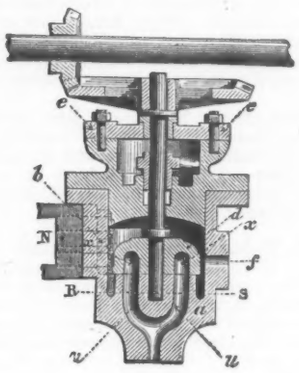


Fig. 3.

The white tubes are those through which the methylic ether circulates. They are always coated with hoar-frost even in the hottest weather. On the right hand a workman is observed withdrawing slabs of ice from the moulds which have been plunged in the saline bath behind him, which is covered with a cloth. Another is seen preparing the decanters of pure water,

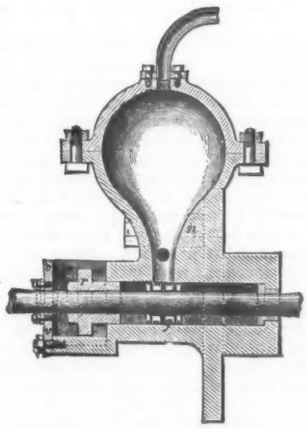


Fig. 4.

which are to be frozen by immersion in another saline bath. Four thousand decanters are frozen daily for use in the cafés and restaurants, and twice or three times that number could be done with equal facility.

In order to fill these decanters, Mr. Charles Tellier has also devised an ingenious kind of cock, which, when turned down, measures exactly the quantity of water required, neither more nor less.

With regard to these frozen decanters (*carafes frappées*, as they are called), it will not be out of place to mention a very interesting experiment upon the congelation of water, which it is easy to repeat.

Most works upon physics assert that upon agitating a mass of water which has been cooled to below freezing point the water partially congeals. This, however, does not take place. These decanters are cooled down to several degrees below freezing point, and may then be shaken as much as one likes without ice forming at all; but if a small crystal of ice, even microscopic, is dropped in, a most striking phenomenon is observed (fig. 6).

The moment the crystal touches the water, long needles of ice start and shoot out in every direction with inconceivable rapidity, forming the most intricate and charming figures; when on a sudden the observer perceives that his eye has only

Fig. 6.

followed one part of the phenomenon which was taking place throughout the mass at the same moment—the water has been solidified.

F. MOIGNO.

Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

§ 1. *Acids, Alkalies, and Salts.*

NITRIC Oxide in Vitriol Making.—F. KÜHLMANN states that the causes which occasion the wide differences in the quantities of nitre used in different vitriol works are almost wholly unknown. It has been conjectured, but not yet proved, that the nitric oxide becomes reduced to a lower oxide of nitrogen or even to free nitrogen, by the sulphurous acid; the author has investigated this reaction, and finds that it does actually take place, and is much promoted by heat and by the presence of spongy platinum. Hence the gases used in the preparation of sulphuric acid must be brought together at the lowest possible temperature at which sulphuric acid can be formed.

Nitre should not be decomposed in the flame of the burning pyrites or brimstone for this reason: Glover's towers should be employed, a weak chamber acid saturated with nitrous vapours being used. *Dingler's Polytech. Journal*, *ccxi.* 24.

Sulphur from Iceland.—C. CARTER BLAKE states that of all localities where sulphur is known to occur, Iceland may claim pre-eminence both for its proximity to Great Britain and the inexhaustible store which it offers. The principal localities where it occurs are Krisuvik, in the south-west, and Lake Myvater, in the north-east. The cost is estimated at £3 per ton, whilst in Sicily, to obtain a ton of marketable sulphur, costs £5 17*s.* 4*d.*, and in Spain £4 11*s.* The Icelandic beds are superficial, wherefore no mining is requisite, and great expense is thus saved. *Chemical News*, *xxx.* 72.

Manufacture of Soda.—W. BLACK and D. HILL patent the following improvements in the manufacture of soda

in revolving furnaces :—These consist in heating the mixture of sulphate of soda, carbonate of lime, and small coal in such a manner as to prevent the formation of caustic lime ; and this may be accomplished by putting the whole mixture of sulphate of soda, carbonate of lime, and small coal into a revolving furnace together, or by heating the carbonate of lime by itself, but stopping short in the heating at that point at which it begins to give off carbonic acid and forms lime, and then adding the sulphate of soda and small coal.

Product of Sodium Sulphate.—W. SMITH states that the process devised by Hargreaves answers well for alkali making, the hydrochloric acid produced often having the sp. gr. 1·16, whilst the saltcake formed often contains 99 per cent. of sodium sulphate, and is sometimes absolutely pure ; it works well during the blackash process.

Hargreaves' process is thus described : A mixture of steam air and sulphurous acid (obtained by burning pyrites) is passed through heated sodium chloride ; the reaction proceeds very uniformly, succeeding best at a temperature just below visible redness ; during the reaction heat is developed, so that but little extraneous heating is requisite. The hydrochloric acid evolved is condensed in the ordinary towers, the saltcake obtained being employed in the usual way in blackash making, &c. Rocksalt is employed pulverized and dried, so that the mass cakes together ; this is broken into lumps the size of stones used for roadmaking, and is placed in iron chambers, four metres high, three long, and two broad. The operation must be conducted slowly to utilize all the sulphurous acid, about 14 days being required ; too high a temperature must not be employed, otherwise the sodium chloride is volatilized ; this salt, also, must not be too dense or too thick. *Chem. Soc. Journal*, 1874, *August*, 823, *from Chem. Centr.*

Improvements in Hargreaves' and Robinson's Process for Alkali making.—HARGREAVES and ROBINSON patent improvements whereby the manufacture of sulphates by the patentees' direct action process is cheapened. These are (1) One of the uptake connecting pipes opens into a high level flue ; (2) A steam pump is used to draw the gases through the converting chambers ; (3) Slide grids with projections fit into cavities on the back support and allow the grids to fall and the sulphates to be removed ; (4) The heated products of combustion are caused to pass by a syphon from between the cylinder top and covering plate into the converting chamber, being filled thence down through an opening in the bottom plate of one of the drawing doors to a chimney ; (5) The outsides of the side grids are made without perforations for from six to ten inches ; (6) For condensing the hydrochloric acid evolved, an oblong tower connected to a set of tubular irons is used ; (7) The converting chambers are each filled from a hopper fitted with a sliding shutter ; (8) the syphons connecting the flues and chambers are made in two pieces ; (9) an aperture is formed on the end of each of the syphons, which enter the converting chambers, and air admitted to cool the chambers ; (10) the chambers are built in two rows at a suitable distance apart, so as to allow drawing of sulphates from the chambers at both sides ; (11) to utilize waste heat from the sulphate apparatus, iron plates with flue spaces beneath them are placed on the top of the arch between the rows of chambers.

Manufacture of Soda.—F. BEILSTEIN states that in Denmark cryolite is worked to a considerable extent for this purpose ; bauxite is preferred in Germany, since America has a monopoly of cryolite. Cryolite contains only 84 to 88 per cent. of pure substance ; this yields on heating with chalk 12 to 13 per cent. of alumina and 60 per cent. of soda. At Oeresund, fluor spar is added to the cryolite, whereby the yield of alumina is increased to 18 per cent. and that of soda to 68 or 70 per cent. ; very pure alumina is thus obtained containing only 0·01 per cent. of iron. *Chem. Soc. Journal*, 1874, *August, pa.* 824, *from Chem. Centr.*

Manufacture of Potash.—H. H. MURDOCK patents the following improvements in the process of obtaining potash from the "yolk" of wool and from the residuum of the distillation of beetroot juice or of molasses, and in apparatus for the same, which improvements are also applicable to the recovery of soda from the lyes of paper pulp.—In these the liquor to be operated on is subjected to evaporation by being made to pass through a series of evaporating pans ; it then enters a preparatory furnace, from which it passes into an incinerating furnace in which the potash is obtained. The potash is then removed to a cooling chamber formed on three sides by double perforated walls with an air span between them, and closed on the other side by a door, the floor being made of bars or girders sufficiently far apart to allow of a circulation of air. The first evaporating pan or boiler is mounted above the preparatory and incinerating furnace, and is heated thereby. The incinerating furnace, which is constructed next to the preparatory furnace, is heated by a firegrate, which also heats one of the evaporators ; a second firegrate gives heat to another evaporator, and also consumes the volatile products of combustion from the incinerating furnace, which products of combustion first traverse the preparatory furnace. Other evaporators are heated by separate firegrates. The flues from all the fires open into a terminal flue heating the last of the evaporators, in which the products of combustion from the different sources are consumed.

Native Potassium Salts.—F. BEILSTEIN states that on the Northern Punjaub, India, minerals containing potash, and identical with the Stassfurth *Sylvine* and *Kieserite* have been found, and that the supply seems likely to be as abundant as that of either Kalusz or Stassfurth. *Chem. Soc. Journal*, 1874, *August, pa.* 823, *from Chem. Centr.*

Iodide of Potassium.—G. LANGBEIN prepares this salt from iodide of copper, which is now imported somewhat largely from Peru ; this substance (containing from 60 to 66 per cent. of iodine) is washed with water to remove soluble matters, and is then finely triturated, and suspended in water acidulated with hydrochloric acid : sulphuretted hydrogen is then passed through the liquid till all the iodide of copper is decomposed ; the sulphuretted hydrogen dissolved in the resulting solution of hydriodic acid is destroyed by adding cautiously a solution of iodine in iodide of potassium, and the whole filtered ; the residual sulphide of copper, &c., is washed, and the washings used instead of water for a fresh batch. On neutralizing the acid filtrate with potash and evaporating, a liquor is obtained from which iodide of potassium separates in crystals on standing ; this concentrated liquor requires straining before running into the crystallizer to free it from a little sulphur.

2177 parts of ore at 66 per cent. of iodine contain 1436 parts of iodine ; actually 1428 parts were obtained in solution by this method. *Berichte der Deut. Chem. Ges.* 1874. *No.* 10.

Bleaching Powder.—RICHTERS and JUNCKER have made a number of experiments on the constitution of this substance ; they conclude that ordinary saturated bleaching powder is not a mixture of calcium chloride and hypochlorite, but that it splits up into these compounds on solution in water. Calcium chloride is present to a small extent in ordinary bleaching powder, owing to the presence of a little hydrochloric acid gas in the chlorine used ; but in well-made samples of bleaching powder, there is not more than about 2 per cent. of calcium chloride. Even when freshly prepared, there is always some calcium chlorate, the amount of which is greater the older the powder, and increases as decomposition proceeds. Decomposition proceeds rapidly when the bleaching powder is exposed to a damp atmosphere.

It is possible to prepare bleaching powder containing between 42 and 43 per cent. of available chlorine. Absolutely dry hydrate of calcium (free from hygroscopic moisture) scarcely absorbs chlorine. The ordinary hydrate contains at 15° about 1·15 per cent. of hygroscopic moisture, which is lost at 60°. This readily absorbs chlorine ; but if mixed with 5 per cent. of calcium chloride, this absorbing power is lost, owing to the deprivation from the hydrate of the hygroscopic water ; hence any considerable admixture of the chlorine used with hydrochloric acid may be prejudicial in other ways than merely destroying so much calcium hydrate by combining with it.

The compound contained in bleaching powder to which the hygroscopic character of the powder is due, is represented by the authors as oxychloride of calcium $CaOCl_2$, united chemically with water. The relative hygroscopic powers of this substance and calcium chloride, are about as 1 and 5.—*Dingler's Polytech. Journal, ccxi.* 31.

Recovery of Manganese in Bleaching Powder Making.—F. KÜHLMANN states that when nitric oxide is made to act on precipitated hydrated oxide of manganese, it is absorbed, together with oxygen, forming nitrate of manganese. When this salt is heated to about 200°, it is decomposed, leaving behind pure manganese dioxide. The escaping gases do not contain any free nitrogen or nitrous oxide, and by passing them over fresh manganous hydrate, give rise to a fresh portion of nitrate. Thus an unlimited medium is afforded for carrying over the oxygen of the air to the manganous oxide ; and the difficulties experienced in working out the process on a large manufacturing scale are believed by the author to be not so great as to prevent its becoming a practical success. *Dingler's Polytech. Journal, ccxi.* 24.

Alumina Salts.—G. ARCHBOLD patents the following improvements in the manufacture of sulphate of alumina or other alumina salts from clay, &c. The clay is dried and powdered, and then made into a mass with some porous combustible, such as spent hops or malt, sawdust, charcoal, &c., and the mixture saturated with heavy coal oils, or other combustible hydrocarbon. After heating the mass, the alumina is rendered more readily soluble in acids than it was previously, so that *neutral* sulphate of alumina can be made from it.

To Detect Metallic Mercury in Commercial Cinnabar (Vermilion).—K. HEUMANN rubbed the samples with water upon bright sheet copper, in the opinion that free mercury would be detected by the appearance of amalgamation. As the copper became amalgamated in every case, whilst no mercury was dissolved out of the samples by dilute nitric acid, it became apparent that copper is capable of decomposing cinnabar. On boiling cinnabar in water with powdered copper, the red colour of the mixture disappears, and is succeeded by a black grey, from the production of sulphide of copper. Powdered zinc had a more energetic action, though here also the sublimed variety appeared more stable than that formed in the moist way. *Berichte der Deut. Chem. Ges. vii.*

Native Cupreous Sulpharseniate. — R. W. E. MACIVOR has analyzed a dufrenoysite from Switzerland, and obtained the following figures :—

Copper	46·05
Silver	2·43
Arsenic	18·79
Sulphur	32·46
	99·73

Small amounts of sulphides of lead and iron were also present. *Chem. News, No.* 770.

§ 2. *Metallurgy.*

Bessemer Pig Iron.—American pig iron contains more sulphur than ordinary English Cleveland pig, the average content being :—

Cleveland pig	0·035 per cent.
American pig	0·207 „

On the other hand, the phosphorus in the American pig is less than that in the Cleveland, viz. :—

Cleveland pig	1·27 per cent.
American pig	0·16 „

The presence of a small quantity of sulphur in a pig iron intended for Bessemer steel, and also containing phosphorus, is beneficial rather than injurious ; provided, of course, the amount of either constituent is not too great ; thus, a pig containing :—

Sulphur	0·15 per cent.
Phosphorus	0·12 „

is better suited for working into Bessemer rails than a pig containing the same amount of phosphorus and no sulphur at all. *Chem. Soc. Journal*, 1874, *August*, 830, *from Chem. Centr.*

Phosphorus in Bessemer Iron.—A. L. HOLLEY states that the amount of phosphorus and other ingredients allowable in Bessemer pig depends on their relative quantities. Either carbon or some metal, such as manganese or silicon, is necessary to give body to steel, and these substances may replace one another. If the steel has 0·15 of phosphorus, and an average amount of other ingredients, it will be made brittle by 0·30 of carbon. But if it contains but 0·05 of phosphorus, other things being equal, it will not be made brittle by 0·75 of carbon. Phosphorus and silicon above, say, 0·10 per cent. produce a decided tendency to cold-shortness. Manganese up to 0·75 does not, of itself, appear to impair toughness, although so large a percentage cannot be allowed in rail steel containing 0·10 of phosphorus, 0·10 of silicon, and 0·30 of carbon. This is not given as an absolute formula, nor even as a general rule for the synthesis of steel. We have too few analyses of mechanically tested specimens to warrant any such close conclusions. It is simply an illustration of the tendency of these outside substances to replace one another as body-givers to steel.

Therefore, equally good Bessemer pig irons may vary considerably ; if they are rich in phosphorus they must be poor in other cold-shortening. If they are rich in copper they must be poor in sulphur and other red-shortening. The phosphorus in Lake Superior Bessemer pig averages about 0·12, but it is quite pure otherwise, and admits of being well blown, *i.e.* thoroughly decarburized, so that the resulting steel is as tough as any in the market. As much phosphorus as this in the English Cumberland irons and in some American irons would tend to produce brittleness. The amount of phosphorus allowable also depends upon the amount of carbon restored by the recarburizer. Of common spiegeleisen, having 10 per cent. of manganese and 5 per cent. of carbon, some 8 per cent. must be put into the blown metal, in order to introduce manganese enough to cure red-shortness, and a good deal of carbon is thus necessarily introduced. Eight per cent. of spiegel added to a well-blown iron will give 0·30 to 0·40 of carbon in steel. But if a ferro-manganese, having, say, 60 or 70 per cent. of manganese, and only 2 or 3 per cent of carbon is employed, so little of it is needed to furnish the requisite manganese that the accompanying addition of carbon is very slight ; hence more phosphorus may be present. This is the basis of the Tessié du Motay process in use at Terrenoire, France. Silicon in Bessemer pig averages about 2½ per cent. As much as this is needed to produce sufficient heat. Some mineral coal pigs contain 4 per cent. and over ; some charcoal pigs have but ¼ per cent. of silicon. The mixture used should have 2 or 3 per cent. Sulphur in Lake Superior Bessemer pig rarely runs above 0·02 ; in Missouri pig, rarely above 0·01. Sulphur in English Bessemer pig averages about 0·10. 2 or 3 per cent. of manganese would be valuable as a purifier, though too much would make the blowing difficult, and it would not take the place of the spiegel. Of other metals there is not likely to be enough to do much good or harm, in such American ores as have been developed, *Iron, No.* 83, *p.* 203, *from the New York Engineering and Mining Journal.*

Improvements in Treating Iron.—E. KIRK patents the use of the following composition :—

Saltpetre	½ lb.
Concentrated potash	1 „
Borax	¼ „
Sal-ammoniac	¼ „

the above quantities being employed per ton of iron.

These ingredients are pulverised and then thoroughly mixed together, and the resulting mixture placed in cans to prevent the action of the air upon the mixture, and also for convenience of transportation. The compound is introduced into the furnace with the iron or ore and the fuel. The effect of the saltpetre upon the iron or ore is to render the iron more homogeneous in its structure throughout the mass, and to produce the same quality of iron in the whole casting. The effect of the concentrated potash upon the iron is to soften the latter materially, and also act as a flux, yielding a greater amount of metal than could be obtained without its use, the latter effect also being increased by the use of the borax in the compound. The object of the employment of sal-ammoniac is to prevent the introduction of the sulphur contained in the fuel into the iron. *Iron, No.* 79, *p.* 70.

Steel.—A. GREINER divides irons and steels into two classes, viz. those which have not been fused and cast into moulds, and those which have been so treated. The first class always contains more or less of slag and heterogeneously constituted metal existing in the blooms ; it includes ordinary irons of the various kinds up to granular iron and steel iron, or puddled steel, which is frequently rich in carbon, so that it can be tempered, and is often no more malleable than Styrian steel, which is a kind of fine wood charcoal pig iron so far decarburized that a simple manipulation in the furnace is enough to render it capable of being hammered and drawn into good steel wire. Cemented irons, or steels derived from iron strongly carburized by direct contact with charcoal, stand at the head of this class.

The second class comprises steels proper, beginning with "very soft steel," which can be welded like iron and cannot be tempered, and terminating with "hard steel," which corresponds to cemented iron or Styrian steel, which can hardly be welded but is readily tempered. In each of the series there are corresponding numbers throughout, the two series running quite parallel ; as the various bodies shade into one another with distinctly marked lines of demarcation, no very sharply defined line of separation can be drawn ; the author gives the following tables :—

Percentage of carbon from 0 to 0·15.

Iron series	Ordinary malleable iron.
Steel series	Very soft steel.

Carbon from 0·15 to 0·45 per cent.

Iron series	Fine grain iron.
Steel series	Soft steel.

Carbon from 0·45 to 0·55 per cent.

Iron series	Steel-like iron or puddled steel.
Steel series	Half-soft steel.

Carbon from 0·55 to 1·50 per cent. and upwards.

Iron series .	. Cemented iron or steel, and Styrian steel.
Steel series .	. Hard steel.

Chem. Soc. Journal, 1874, *August*, 830, *from Chem. Centralb.*

Welding.—In welding iron, as is well known, the pieces are heated to whiteness. When iron is to be welded to iron this plan answers well enough; but if iron is to be welded to steel the white heat often destroys the steel completely. To remedy this evil a patent has recently been taken out in America which promises to remove all difficulties. By this process the surface of the metal to be welded is moistened with water, and on the wet surface there is sprinkled a compound consisting of 1 lb. pulverized calcined borax, 1 lb. fine iron filings, and 4 oz. pulverized prussiate of potash intimately mixed. The two surfaces are then wired, or otherwise held together, and raised to a red heat, or about 600° to 700° F. When subsequently subjected to rolling or hammering the joint is completed, whilst the steel is not sufficiently raised in temperature to be at all injured by the operation. *Iron, No.* 82, 173.

Welding and Refining Steel.—C. SCHILD patents the use of a compound composed of the following ingredients :—

Carbon	3 oz.
Sulphate of iron	4 „
Copperas	6 „
Litharge	3 „
Saltpetre	3 „
Prussiate of potash	3 „
Red oxide of iron	3½ „
Black oxide of manganese	3½ „
Iodide of potassium	4 drachms.
Pulverized charcoal	4 oz.
Common salt	1 lb.
Pulverized clay or sand	20 lbs.

These ingredients, with the exception of the clay or sand, are pulverized, and thoroughly mixed together in a vessel, without regard to order of precedence. The clay or sand is then heated to about 100° F., after which the other mixture is mixed therewith by means of a hoe or other suitable tool. This mixing or intermingling of the ingredients should be of the most thorough character, so that the various articles will be perfectly blended together. The composition or compound is then in the shape of a powder, and is ready for use. It is applied in the usual manner by sprinkling the powder over the parts to be welded, and then giving them the proper heat in the forge fire. It is also used for refining and regenerating.

Steel-melting Furnaces.—A. C. LEWIS patents furnaces for melting steel. Such furnaces are usually made square, or nearly so, and receive four crucibles, or pots, placed quadrangularly at about equal distances from each other, and from the sides of the furnace. This invention is made for the purpose of equalising the action of the heat upon the pots, and obtaining great uniformity in the time of melting and in the quality of the metal obtained. The pots also last much longer, and time is saved, because the metal is more rapidly melted. The invention consists of a long, narrow, and deep furnace, adapted to receive four pots in a row, and proportioned with reference to obtaining uniformity of fuel and heat spaces all round the pots employed. Each part of each crucible being thus subjected to nearly the same temperature, the melting of the steel proceeds with uniformity and rapidity, and the pots are not liable to be broken from inequality of temperature. Metallic plates form the enclosure for the furnace. These are placed in the earth and contiguous to the wall, so that the attendants are above the furnace, and the escape heat passes by the flue beneath the steam boiler for an engine, or is otherwise economized. The lining is of fire-brick, is supported by ledges around the inside of the metallic case, and the grate-bars support the fuel and pots. The removal covers serve to give access to the furnace from above. The pots are placed in a row within the furnace and surrounded by the fuel. The internal measurements of the furnace are such, in comparison with the pots as placed in a row, that the distances between the pots and between the sides of the furnace and the pots are uniform, or nearly so; thereby the action of the fuel is the same on all sides of the respective pots, and the reflected heat from the interior of the furnace walls being equal on all parts of the pot, and the depth of the furnace being more than twice the height of the pots, prevents the pots being cooled even when the covers are removed for inspecting the crucibles. The ash-pit is closed by a door or stopper, and the blast of air from a blower is introduced through an opening of about four inches in diameter, placed so as to equalise the action of the air with respect to the escape flue. *Iron, No.* 79, *p.* 70.

New Sources of Metallic Ores.—The director of the Bureau d'Essais, Paris, states that the growing demand for nickel has created an active search for ores of that metal; many specimens from Piedmont and Spain were assayed, but found to contain a very small quantity of the metal. Many attempts have been made to find a substitute for nickel in alloys composed of it with copper and zinc, but apparently without result.

Grey ores of copper from Alger and Constantine were analyzed and found to contain, in some instances, mere traces of silver, while others yielded 800 to 2,200 grammes of that metal per ton of the ore. Some grey copper ore, containing a small quantity of copper pyrites from St. Etienne de Baigorry in the Basses-Pyrénées, yielded 310 kilogrammes of copper, and 10·550 kilogrammes of silver per ton. A collection of old copper scoria brought from the neighbourhood of Huelva was found to contain copper varying from a mere trace to 1·60 per cent.

An important series of minerals of copper pyrites from Japan was analyzed. The specimens from the mines of Betchi, situated to the west of the island of Sitkokf, consisting of quartz and talc-like chlorite with copper pyrites, contained neither gold, silver, arsenic, nor antimony, and the metallic copper melted in the country itself was found to contain 3·420 per cent. of lead, 0·012 of tin, traces of iron, and very slight traces of arsenic and antimony. The large percentage of copper is attributed to additions of that metal during smelting, and not to accident.

Numbers of iron ores from the great oolithic formation of the north-east of France were analyzed, but furnished no new facts. Specimens from the three provinces of Algeria, oxidulated iron, oligiste, red oxide, and brown hæmatite, were found in some cases to contain a very sensible quantity of manganese, and to resemble pretty closely certain rich Spanish ores.

Numerous examples of lead ore were also received from Algeria. They consist principally of mixtures of galena and blende, and the sulphites are replaced partially or entirely by carbonate of lead or calamine. Many deposits of lead ore are found with those of grey copper, but they contain very little silver, the yield of many samples not exceeding 20 grammes of silver per 100 kilogrammes of lead; others yielded from 50 to 80 grammes. In the regency of Tunis, lead ores are also found associated with zinc ores, and generally poor in silver, the highest percentage of silver found being 125 grammes per 100 kilogrammes. *Iron, No.* 79, *p.* 68.

Extraction of Bismuth from its Ores.—A. CARNOT gives the following process for the extraction of bismuth from an ore consisting of sulphide, oxide, and hydrated carbonate, and also containing lead and tungsten; the mineral is coarsely powdered and heated with hydrochloric acid, and the insoluble portion, heated twice more with fresh portions of acid, used subsequently for new batches of fresh ore; bars of iron are placed in the clarified liquor, whereby the bismuth is precipitated as a metallic powder; this is collected, washed, squeezed in cloths, and quickly dried in a stove; finally, it is melted in a plumbago crucible, covered with carbon to prevent oxidation, and poured into moulds; a little arsenic, lead, and antimony are still present. *Annales de Chim. et de Physique* [4], *xxxi.* 403.

Alloys of Tin.—The number of alloys into which tin enters is legion. Tin alone is not adapted to making castings, but, added in small quantities to other metals, gives them hardness. A few of its most important alloys are given below, together with the usual proportions :—Britannia metals average nine parts tin and one part antimony; pewter, six parts tin and one part antimony, with various other metals, as bismuth, copper, lead, zinc; soft solder, equal parts of lead and tin, two parts tin and one of lead, or one part tin and two of lead. The less lead it contains the lower its melting point will be. Bronze consists of copper and tin, or copper, tin, and zinc; the chief varieties are bell metal, gun metal, and statuary metal. Ordinary bell metal consists of seventy-eight parts copper and twenty-eight of tin; gun metal of ninety parts copper and nine of tin; the statuary bronze used in the statue of Louis XIV., at Paris, made in 1699, consists of copper, 91·40; zinc, 55·3; tin, 1·70; lead, 1·37. An alloy of tin and mercury has long been in use for mirrors. *Iron, No.* 8, *p.* 139.

Melting Points of Lead-tin Alloys.—R. GNEHM gives the following numerical values :—

Composition of Alloy. Tin.	Lead.	Point of Softening.	Point of Fusion.
2 parts	5 parts	185	189
2 „	6 „	189	194—195
2 „	7 „	192	198
2 „	8 „	202	208—210

Chemical News, xxx., 53, *from the Moniteur Quesneville.*

Welding Copper.—M. BENSON patents improvements consisting in heating borax until all its water of crystallization is evaporated, then pulverizing the dry residuum. After the two pieces of copper to be welded are prepared, borax is applied between the surfaces and the pieces hammered together when hot. The joint thus prepared is brought to a white heat, powdered over quickly with chloride of magnesium, chloride of sodium (salt), or with any of the chlorides most suitable for the purpose of excluding the oxygen, and finally welded. Another method by which this weld can be effected is by directing a stream of chlorine gas upon the heated copper during the process of welding.

Precipitation of Copper.—T. S. HUNT patents improvements in precipitating copper by means of tin scrap. This invention consists in using tin-plate scrap or waste for the precipitation of copper from the solutions obtained in the various wet processes of copper extraction, and in saving in the operation the adhering tin. The copper solution must contain at the same time chloride of copper and sulphate of soda, or some other base. Such solutions are obtained from sulphuretted copper ores, which have been calcined with common salt, as in the Longmaid or Henderson process, or when similar ores after roasting are digested with chlorides of iron or other chlorides, as, for example, in the Hunt and Douglas process. In case, however, the solutions of copper to be precipitated contain no chlorides, a portion of common salt is added, and in case they contain no sulphates, a portion of sulphate of soda or other soluble sulphate is added. In either case, these salts may equal the amount of copper present. Such solutions, containing both chlorides and sulphates, especially if heated, as is usual in copper precipitation, very quickly dissolve the tin from tinned iron when this is immersed therein, and at once let it fall again as an insoluble hydrated oxide of tin, which may be readily drawn off while suspended in the liquid, and collected by subsidence in proper tanks, to be subsequently treated by methods known to chemists, such as dissolving in hydrochloric acid and precipitating by metallic zinc, by reduction in the dry way, or by conversion into stannate of soda. The scrap iron thus freed from tin is then employed in the ordinary way to precipitate the dissolved copper, as metallic or cement copper, from the solutions described. The copper solution, holding the suspended oxide of tin, may be drawn off at once from the iron to the settling tank, and a fresh solution added; or the precipitation of the copper may be carried on without interruption in the first solution till this is exhausted, and the oxide of tin afterward separated from the metallic copper by taking advantage of the greater lightness and the more finely divided state of the former. Should it be desirable to remove the tin from the iron plate without causing an immediate precipitation of copper thereon, this may be effected by mixing a solution of perchloride, or other persalt of iron, with the copper solution.

Pure Gold.—W. CHANDLER ROBERTS states that perfectly pure gold is obtainable by reducing gold chloride by oxalic acid and fusing in a clay crucible with bisulphate of potash and borax. The gold obtained by electrolyzing the double cyanide of gold and potassium contains 999·90 of fine gold per mille, whilst the product of the reduction of the chloride with sulphate of iron and subsequent fusion contains only 999·85 per mille. *Fourth Annual Report of the Deputy-Master of the Mint.*

Imitation Gold.—A new alloy has been introduced as a substitute for gold. It is said to be capable of being cast, rolled, drawn, stamped, chased, beaten into a powder or leaves, and to be absolutely indistinguishable from gold, except by practised experts. The article consists of one hundred parts pure copper, seventeen parts zinc or tin, six parts magnesia, nine parts tartar of commerce, one-half part sal-ammoniac, and one-eighth part quicklime. The copper is first melted, then the magnesia, sal-ammoniac, lime in powder are added, little by little, and thoroughly mixed by a brisk stirring for half-an-hour, after which zinc is thrown on the surface in small grains, stirring it until entirely fused. The crucible is then covered, and the fusion maintained about half-an-hour, when the dross is skimmed off, and the material is ready for use. *Iron, No.* 80, *p.* 113.

§ 3. *Dyeing, Calico Printing, Bleaching, Tanning, and Allied Subjects.*

Aniline Yellow and Orange.—F. SPRINGMÜHL states that many of the dyes met with in the market under the names of aniline yellow and orange, are really derived from other coal-tar products, such as phenol, naphthalene, and anthracene. Many are mixtures of several of these products, sold under the names of Victoria orange, xanthine, &c. The microscope often affords the means of distinguishing such mixtures; or the difference of solubility in water of the different constituents, or the different action of alkalies, acids, &c., may be employed to discriminate them.

Picric acid is a most frequently occurring constituent; this may be detected by the characteristic isopurpuric acid reaction with cyanide of potassium, or by the production of chloropicrin, on treating with chloride of lime. Ammonium trinitro-cresylate, naphthalene yellow, and the true aniline yellow (chrysaniline) are also frequently met with.

Aniline orange is mostly chrysaniline mixed with more or less rosaniline; arsenic is often present, as much as eight per cent. having been found in one sample; inorganic ash left on incineration often constitutes a considerable percentage. Oranges, consisting of naphthalene yellow, or ammonium trinitro-cresylate, mixed with a red colouring matter, are of frequent occurrence. *Chem. Soc. Journal*, 1874, *August*, 835, *from Chem. Centr.*

Methylaniline.—A. W. HOFMANN states that commercial methylaniline boiling at 190-193 often contains aniline and dimethyl-aniline; the former of these is easily separated by adding dilute sulphuric acid until no more aniline sulphate crystallizes out, and then distilling the liquid portion with an alkali; the regenerated dry bases are then treated with acetyl chloride. On dissolving the product in hot water methyl acetanilide crystallizes out, and dimethyl aniline remains in solution as hydrochloride; from the methyl acetanilide pure methyl aniline can be obtained by boiling with hydrochloric acid.

Pure methyl aniline gives no violet colour in the bleaching powder solution, whereby it is sharply distinguished from ordinary aniline. *Berichte der Deut. Chem. Ges. vii.* 523.

Manufacture of Artificial Alizarin.—A. OTT states that the method mostly used is that described in the patent specifications of Gräbe, Liebermann, and Caro, consisting in the oxidation of anthracene to anthraquinone, the conversion of this into anthraquinone-disulphonic acid, and the fusion with caustic soda of the sodium salt of this acid. To prepare the anthraquinone Nienhaus uses:—

Anthracene . . .	100	parts.
Bichromate of potash. .	25	„
Nitric acid sp. gr. 1·05 .	12	„

whereby a smeary mass is produced, becoming granular after a moment's contact with fuming nitric acid. Ordinary commercial anthraquinone requires purifying by heating to 70° with concentrated oil of vitriol; sulphurous-acid is evolved, and on addition of water the purified product is precipitated; this is washed and dried at 50°, and converted into the disulphonic acid by heating to 270-290° with four to five times its weight of fuming sulphuric acid; some anthraquinone sublimes during this heating; this is regained by setting the vessels in connection with a wooden condensing chamber.

The product is a black pitch-like mass, solid when cold; this is decomposed by chalk, and the soluble lime-salt thus produced is mixed with carbonate of soda; carbonate of lime is thus thrown down, and a solution of anthraquinone disulphonate of sodium produced; this is evaporated down till it has a density of 20° B.; on cooling a solid separates, which yields alizarin with a bluish cast on fusion with caustic soda, whilst the mother liquor yields on similar treatment alizarin with a yellow shade, the difference being probably due to the presence of the more soluble monosulphonate in the mother liquor. *Chemical News, xxx.* 113.

Detection of Saffranin.—Saffranin can be readily distinguished from rosaniline by treating a portion of the dye-stuff with strong sulphuric acid, which dissolves rosaniline, producing a brownish yellow liquid, whilst the solution of saffranin is green, ultimately becoming blue. Dilute solutions of rosaniline are transparent and crimson both by transmitted and reflected light, whilst similar saffranin solutions are turbid opaque and scarlet by reflected light, rose-coloured and transparent by transmitted light. Fibre dyed with rosaniline is partly decolorized by five per cent. soap lye, and wholly by soda lye, or by contact with hydrochloric acid and a sheet of zinc; whilst if dyed with saffranin the soap lye produces no change at all, and the soda lye and zinc and hydrochloric acid but little; in the last case the dyed fabric becomes yellow after long treatment. *Reimann's Färberzeitung, No.* 19, 1874.

Dressing for Textile Materials.—J. H. JOHNSON patents the use of a new preparation, entitled "Guignet's dressing," for the dressing, preservation, and rendering impermeable of textile materials either in the raw or manufactured state, wood, ligneous products, and the various kinds of paper. To

obtain this preparation, a metallic soap is produced by double composition by the aid of a solution of a metallic salt, such as sulphate of alumina, of iron, or of copper, and of a soluble soap such as Marseilles soap, or resinous soaps. These substances are mixed together by agitation either cold or warm. When treated warm, the insoluble soap in the water melts and comes to the surface, and may be skimmed off; when treated cold, the separation is obtained by filtration. The soap, which is insoluble in water, is dissolved for use in a light oil of tar, petroleum, or other volatile hydrocarbon, in essences, sulphide of carbon, or any other solvent which does not leave any residuum by evaporation. In employing this preparation, it is desirable to heat it slightly. The threads, ropes, fabrics, or other materials, are first well dried, and then immersed. The solvent evaporates by exposure, leaving the material, or the evaporation may be effected in distillatory apparatus, so as to recover the solvent for re-utilisation. Other substances may be added to the solvent in order to modify the colour and properties of the preparation. The insoluble soaps may be dissolved in small quantities in drying oils, and thus serve for the preparation of a paint or coating possessing valuable preservative properties.

Size for Cotton Yarns.—H. WEGMANN patents an improved compound for sizing cotton yarn, consisting of tallow, soft soap, resin, vitriol of iron, and onions. This compound is designed to be added to 25 lb. or 75 lb. of starch, or 50 lb. to 100 lb. of flour, the resin, vitriol, onions, and tallow being boiled till rendered sufficiently liquid to mix freely with the other matters; then the soap is melted in a tank separately, by hot water and steam, and the above mixture added. The ingredients are thoroughly mixed with steam, and then added to the starch or flour in another tank, together with the proportion of water requisite for making the sizing more or less stiff, according to the size of the yarn for which it was intended, the starch or flour being also varied to suit the case in hand.

Fixations of Iron and Alumina Mordants on Calicoes.—Chocolate reds, blacks, purples, and catechus with madder, garancin or alizarin, are aged for forty-eight hours at a temperature of 35° and 32° moisture on the psychrometer; double roses and brightened reds for forty-eight hours at 27° moisture and 30° temperature. Aniline blacks require twenty-four hours at 28° moisture and 38° temperature. Madder reds and alizarin with aniline black require firstly twelve to eighteen hours at 30° moisture and 36° temperature, and then twenty-four hours at 27° moisture and 30° temperature.

The time required for ageing may be shortened by adding just before use to colours with iron mordants (such as chocolates and purples) one-twelfth part of the following oxidizing mixture:—

Soda crystals	4·2 kilogs.
Arsenious acid	2·8 „
Water	36 litres.
Dark roasted starch	17·5 kilogs.
Potassium chlorate	3·2 „

Alumina mordants may also be fixed by exposure to air charged with ammonia, and iron mordants by dunging in a mixture of silicate of soda and liquid ammonia. This latter process, however, is not applicable to aniline blacks or to alumina mordants.—*Chem. News, xxx. 53, from Moniteur Quesneville.*

For garancin catechu styles in cases of imperfect oxidation, two or three grammes of bichromate of potash per litre may be added to the dungbath. With iron mordants for purples, garnets, &c., five to ten grammes of hypochlorite of ammonia per litre may be added to the dung-bath. This salt is made by adding together—

Liquid ammonia	140 grammes
Water	150 „
Sulphuric acid	50 „

whereby sulphate of ammonia solution at 12° B. is obtained. Of this take forty grammes, and add of bleaching powder liquor at 3½° B., 100 grammes.

Calicoes may be instantaneously aged by treatment in the following bath:

Water	7 litres
Potassium chlorate	60 grammes
Magnesium chloride at 15° B.	¼ litre
Nitrate of ammonia	30 „

After drying, the pieces are printed with the required alumina and iron mordants. For reds with alumina acetate, somewhat more tin crystals are required when this oxidizing liquor is used, than when the goods are aged in the ageing-room. On the other hand, oxidation by deliquescent salts economizes garancin for puce grounds to the extent of 600 or 700 grammes per piece of 100 metres.

Chlorate of soda may be economically made by first preparing the hypochlorite from bleaching powder and carbonate or sulphate of soda, and then boiling the solution till wholly converted into chlorate.

When oxidation is complete and the colours have been printed on, the fabric is dunged, to complete the fixation of the mordants and to remove thickening, &c. Silicate of soda can often be used successfully, instead of cowdung and chalk. For double roses (alizarin and fleur de garance) two vats are used, fitted with rollers, and communicating by a tube 5 centimetres in diameter; each contains 4,500 litres of water. The first is charged with 40 litres of silicate at 20° B., the second with 30 litres: a piece is passed through these vats in three minutes; one washing then follows for light patterns, two for heavy ones; the goods are then again dunged for twenty minutes in the following baths at a temperature of 50° C.:—

Water	600 litres
Silicate, at 20° B.	3 „

They are then washed twice. For very heavy patterns a third dunging and two more washings may be required.

Garancin styles, black-browns, catechus, purples, and fleur-de-garance, or alizarin browns, are dunged as above described, the first vat containing 60 litres of silicate, the second 50. In England a mixture of phosphate of lime and soda, arseniate of potash or soda, and chalk, is often used. This gives good results with garancin styles and heavy madder reds, and corrects imperfect oxidation of the iron mordants. The first vat contains to 4,500 litres of water, 5 litres of the following mixture, stirred up before use:—

Diarseniate of potash	8 kilogs.
Dung substitute	4 „
Boiling water	20 litres
Chalk (added when cold)	8 kilogs.

The second contains the same, and also 5 kilogs. of chalk well ground up with water; the pieces are passed through at 70° C. and washed, and are then dunged again in the following bath:—

Above mixture	1 litre.
Water	800 „
Chalk	1 kilog.

After washing the goods are passed into water at 55° for twenty minutes, and are then dunged a third time for twenty minutes at 50° C. in the same bath as that used for the second dunging; after washing the pieces are then fit for dyeing.

As little delay as possible must be occasioned between all these various operations. *Ibid. p. 54.*

Improved Composition for finishing Calicoes, Velvets, and other Cotton and Silk Goods.—C. WATTERSON patents the use of the following mixture:—A ton of castor-oil, olein, or oleic acid is put into a pan capable of holding three tons, to which is added 8 cwt. of caustic-soda, containing 22 per cent. of alkali and 200 gallons of water. The mixture is boiled slowly for twelve hours, after which a ton of cocoanut-oil olein is added, then 5 cwt. of caustic-soda, and the mixture thus obtained boiled for ten hours; three gallons of strong ammonia or caustic potash at 60° (Twaddle's hydrometer) is then added, and the whole increased by water up to three tons, adding potash, or soda, or ammonia as required.

Tanning Materials.—P. P. F. MICHEA patents improvements relating—(1) to a process for the production of tannin from tannin-bearing plants, trees, fruits, leaves, barks; and (2) to the application of such process to the production of a substance from the leaves of the *Canocarpus latifolia*, known as canocarpine, described in a patent of 1872 (No. 2,786). The tannin contained in the plants, trees, &c., is first extracted by maceration in an aqueous solution of common salt, in sea water, or in a solution of sulphate of soda, to which about 1 per cent. of a soluble salt of lime or magnesia is added. From the liquid thus obtained the tannin is precipitated by the addition of an alkali. The tannin compound thus precipitated is washed and suspended in water, and by the gradual addition of a free acid the precipitate is dissolved and a solution of tannin obtained. For producing canocarpine a decoction of the said leaves is subjected to fermentation until the tannin is destroyed, and the fermented liquid is then subjected to the above-described process.

§ 4. *Food, Water, and Sanitary Matters.*

Putrefaction of Meat.—J. LEFORT states that meat which contains the most calcium phosphate putrefies the quickest. The putrefaction of meat commences near the bone for this reason.

Fishes' flesh contains much more phosphoric acid than ordinary butcher's meat, *e. g.* :—

	Percentage of phosphoric acid.
Skate	0·514
Mackarel	0·532
Fillet of beef	0·395
„ veal	0·374
„ pork	0·430

Hence it is more liable to change and undergo decomposition. *Pharm. Journal, xix.* 257 *and* 354.

Condensed Milk.—A. MUNTZ gives the following analysis of the consolidated milk prepared at Cham, Canton Zug :—

Specific gravity, 1·313.

	No. 1.	No. 2.
Cane sugar	38·8	29·4
Inverted sugar	1·7	12·4
Milk sugar	13·3	13·9
Butter	9·5	8·5
Caseine, albumen, and salts	11·0	12·0
Water	25·7	23·8
	100·0	100·0

The amount of inverted sugar increases in keeping. The original milks from which these were prepared by evaporation must have had the following compositions, closely approaching that of average pure milk :—

	No. 1.	No. 2.	Normal milk.
Milk sugar	5·2	5·2	5·2
Butter	3·7	3·2	4·0
Caseine, &c.	4·3	4·4	3·8
Water.	86·8	87·2	87·0
	100·0	100·0	100·0
Total solids.	13·2	12·8	13·0

Chem. News, xxx. 66, *from Bull. Soc. d'Encouragement.*

Injurious effects of Soda Manures on Beetroot.—When nitrate of soda is used as manure for the sugar beet unsatisfactory results are sometimes obtained, due to the fact that the soda salts present in the soil assist in increasing the amount of uncrystallizable sugar, and correspondingly diminish the quantity of crystallized sugar obtainable. 1,000 kilogs. of pure nitrate of soda would contain 364·7 kilogs. of soda, equivalent to 835·3 kilogs of sulphate of soda ; and this would suffice to convert 3,758·7 kilogs. of sugar into molasses. *Les Mondes, No.* 12, 1874.

Chalybeate Waters.—L. F. CARO states that the spring at Pyrmont has no chalybeate taste at the ordinary temperatures, but possesses a strong taste as the temperature is raised up to 40°. This is apparently due to the production of double decomposition between the ferrous carbonate and calcium sulphate present in this water. *Arch. Pharm.* [3] *iv.* 145.

Corrosion of Tin and Tin-lined Pipes by Water.—KNIGHT and SON state that during twenty-five years' experience of the use of tin and tin-laid lead pipes, in no instance have they failed to discover more or less corrosion of the inner surface of such pipes as have been exposed to the action of water for a year. Spring and well water seem to act on the tin more quickly than river or pond water. After ten or twelve years' use, in many instances, the old pipes were so corroded as to be useless, some portions being so corroded as to crumble with a touch, others being apparently smooth and free from corrosion. In one case, where a pipe was used partly of tin-lined lead, partly of lead alone, the former was so much corroded that in many places the tin was wholly eaten through, whilst the latter, and also the solder joining the two (probably about equal parts of lead and tin) was perfectly bright and smooth, and free from the slightest action. Probably the corrosion of tin in this way may be explained by the (galvanic ?) action of particles of impurities, foreign metals, &c. in the commercial tin used in the manufacture of the pipes. *Chem. News, xxx.* 46.

Suspension of Clay in Water.—W. DURHAM finds that the power possessed by pure water of retaining fine clay in suspension is gradually *destroyed* by the addition of a very minute quantity of an acid or of a neutral salt, and gradually *increased* by the addition of alkalies, or their carbonates, or of lime. In solutions of sulphuric acids and of common salt, the more dense the solution the less quickly the clay falls, whilst the opposite holds with solution of sodium carbonate. The following table exhibits the relative rates of clearing turbid liquids containing clay in suspension :—

Liquid.	Density.	Time of clearing. h.	m.
Pure water	1,000	36	0
„ with two drops of acid per pint.	1,000	0	30
„ with acid	1,024	1	30
„ „	1,048	5	0
„ „	1,093	10	0
„ „	1,440	36	0
„ with 1 grain sodium carbonate per pint	—	96	0
„ „ 5 „ „	—	112	0
„ „ 9 „ „	—	93	0
„ „ 20 „ „	—	46	0
„ „ 30 „ „	—	22	0
„ „ 200 „ „	—	4	0

Paper read before the Edinburgh Physical Soc., also Chem. News, xxx. 57.

Tobacco.—J. R. MCD'IRBY and J. A. CABELL have made a large number of analyses of various kinds of Virginia tobacco.

1. Light yellow. "Coal-cured wrapper" for cigars.
2. Light yellow. "Fine smoking."
3. Medium brown colour. "Sweet fillers."
4. Dark. "Austrian cigar wrappers."
5. Dark. "English shipping."
6. Dark. Exported to France for snuff.

	1.	2.	3.	4.	5.	6.
Average length of bundle in in.	18	15½	19	21	22	20
Average weight of bundle in oz. avoir.	2·65	2·5	2·82	4·0	4·58	5·37
Total percentage of ash	11·803	15·394	18·518	16·313	18·177	15·905
Pure ash (sand, carbonic acid, alumina, and iron deducted)	8·943	9·292	12·340	14·839	13·391	11·062
Total nitrogen	3·183	2·633	3·725	5·762	5·333	5·258
Nitrogen in form other than nicotine	2·608	2·013	2·813	4·538	4·262	3·727
Nicotine	3·325	3·586	5·276	7·086	6·202	8·862
Ratio of nitrogen as nicotine to total nitrogen reckoned as 100	18·2	23·6	24·5	21·3	20·1	28·9

The following table exhibits the average composition of the "pure ash" (carbonic acid, sand, oxide of iron, and alumina being deducted) from these six samples as compared with that of Kentucky, European, and New England tobaccos.

	Virginia.	Kentucky.	New England.	Europe, including Turkey.
Number of specimens examined	6	30	12	13
Silica	1·717	2·728	0·845	10·262
Chlorine	2·812	3·741	9·360	4·920
Anhydrous sulphuric acid	5·490	4·209	6·582	4·304
„ phosphoric	3·296	4·988	3·563	3·217
Oxide of potassium	35·576	37·568	34·964	18·008
„ sodium	2·784	2·105	1·993	4·289
Calcium	37·600	35·308	34·481	43·511
Magnesium	10·725	9·353	8·212	11·459
	100·000	100·000	100·000	100·000

The high percentage of chlorine and small quantity of sodium in the New England tobaccos are remarkable ; possibly this is due to manuring with Stassfurth potash salts.

Heavy, dark, shipping tobaccos appear to contain more phosphate than the finer and lighter qualities ; probably this is connected with the coarse rank growth and large proportion of nitrogenous matter noticed in the case of the former qualities. *Chem. News, xxx.* 117.

Cure for Sea-Sickness.—J. M. SMITH patents the following composition to be used as a plaster for the prevention of sea-sickness :—Take of what is known as diachylon (an oxide of lead and oil), two grammes ; with this thoroughly mix two grammes of theriac, or Venice treacle, and one gramme of extract of bella-

donna, and preserve the compound in a tight-stoppered vessel. To use the compound as a preventive or cure for sea-sickness, spread it to about the thickness of an ordinary adhesive plaster on a small oval piece of kid or other soft leather. One of these plasters being slightly warmed, is applied and caused to stick on the pit of the stomach.

New Cure for Hydrophobia.—J. JITZKI states that the venom of the common viper (*Coluber berus* or *Vipera berus*) is a cure for and prophylactic against the poison of rabies.—*Chemical News, xxx.* 121, *from Les Mondes.*

Analysis of Sugar.—J. M. MILNE states that the usual plan of taking a weighed quantity of the sample, dissolving in water, and making up to a given bulk, and using the liquid so obtained for the determination of the fruit sugar, is by no means always to be relied on, because many dark-coloured sugars contain other substances (probably albuminous) besides the fruit sugar capable of reducing copper solution, and these must first be separated before correct results can be obtained. The method recommended by Fresenius, of adding lead acetate to the sugar solution till no further precipitate is formed, may be advantageously employed for this purpose.

The following method of procedure answers very well:—5 grammes of the sample are dissolved in a moderate quantity of water, and the insoluble matter allowed to subside. The supernatant liquid is then carefully poured into a 100 cc. flask, the insoluble treated with more hot water and finally collected on a small weighed filter, and the washing continued till the flask is about three-quarters full. To the sugar solution a little solution of tribasic acetate of lead is added, the whole well shaken, and the precipitate allowed to subside. The clear liquid is then tested with a drop or two of acetate, and, if no further precipitate is produced, the contents of the flask are cooled to the proper temperature, and finally made up to the mark with water, the whole being thoroughly mixed. When the precipitate has subsided, the liquid is passed through a *dry* filter into a clean dry glass, and, when sufficient has passed through, is ready for the fruit-sugar determination. If it is desired to determine the extractive matters *directly*, the precipitate in the flask is washed several times by decantation, and then placed in the filter (previously weighed), and the washing continued till a drop of the filtrate no longer gives a precipitate with sulphuretted hydrogen; the filter and contents are then dried as usual. By the above method of treatment a clear colourless solution is always obtained, which renders the further operations with the copper liquor much easier.—*Chem. News, No.* 77.

Method of detecting Meat-fats when mixed with Butter.—J. HORSLEY says that fresh butter is permanently soluble in methylated ether, sp. gr. 0·730, at the temperature of 65° F. (20 or 25 grains of fresh butter to 1 dram of methylated ether). On adding 30 drops of methylated alcohol, 63° O.P., nothing is precipitated. When 15 grains of fresh butter, and 10 grains of mutton fat are dissolved in 1 dram of ether and 30 drops of alcohol added, in less than half an hour the fat is precipitated, in a room heated to 68° F. Mixtures of known fats, such as lard, beef, mutton, and tallow fats, properly melted together in proportions of 60 grains of butter, and 40 of fat, and stirred till cold, are similarly precipitated in a few minutes.

[*Note by Abstractor.*—It seems exceedingly doubtful if the rough test above described will yield results that can be relied on in cases of adulteration with small quantities of fat; moreover the question of the possibility of deposits being obtained from old samples of butter, butters from different breeds of cows, &c., remains wholly untouched. R. G.]

§ 5. *Fuel, Gas, Illumination, &c.*

Gas Purification.—LAMING'S purifier consists of lime and oxide of iron. After use it is saturated with ammonia, sulphur, and cyanogen compounds; the ammonia salts are extracted by treatment with water, after which the cyanides are dissolved out by means of lime; on adding potassium sulphate to the solution, potassium ferrocyanide is formed. The insoluble iron sulphide left is used as a source of sulphur, and the residual iron oxide left after the sulphur has been burnt off is employed over again for gas purification. *Dingler's Polytech. Journal, ccxi.* 76.

Manufacture of Anthracene.—E. LUCAS patents the following improvements:—The anthracene is obtained from the heavy coal-tar oils which distil at from 260° to 360° Celsius, by passing the same or the vapours thereof through pipes or retorts previously raised to a red heat. The heated surface is increased by filling the pipes or retorts with pieces of firebrick. The oil obtained by this operation is submitted to distillation, and the distillate which passes over after 360° Celsius, is collected separately, cooled, and pressed, the press cake thereby obtained being crude anthracene. The liquid oil resulting from this distillation is again passed through red-hot pipes or retorts, and another portion of anthracene is obtained therefrom.

The Coal Supply.—PECHAR and PEEZ report on the coal industries of all nations. The following table gives the comparative production of coal in different countries in the years 1866 and 1872, in metrical tons (of 2,000 German pounds each):—

Countries.	Year.	Production.	Year.	Production.	Percentage of Increase.
England . . .	1866	103,069,804	1872	125,473,273	21·73
Germany . . .	1866	28,162,805	1872	42,324,469	50·27
United States .	1866	21,856,000	1872	41,491,135	89·83
France . . .	1866	12,260,085	1872	15,900,000	29·68
Belgium . . .	1866	12,774,662	1872	15,658,948	22·57
Austro-Hungary	1866	4,893,931	1872	10,443,998	113·41
Russia	1866	264,455	1872	1,097,832	315·13
Australia . . .	1866	774,000	1872	942,510	21·77
Other countries	1866	638,000	1872	2,943.659	361·38
Total . .	—	184,693,742	—	256,275,824	38·75

The following table gives the proportion of coal production in 1872 due to the several countries:—

Countries.	Production in 1872, in metrical tons.	Percentage of total Product.	Population.	Coal production per head, in pounds.
England . . .	125,473,273	48·96	31,817,108	7,887·15
Germany . . .	42,324,469	16·52	41,058,139	2,061·68
United States .	41,491,135	16·19	38,650,000	2,147·02
France . . .	15,900,000	6·20	36,469,875	871·95
Belgium . . .	15,658,948	6·11	5,087,105	6,156·33
Austro-Hungary	10,443,998	4·07	35,904,435	581·76
Russia	1,097,832	0·43	82,172,022	26·72
Australia . . .	942,510	0·37	1,958,650	962·40
Other countries	2,943,659	1·15	260,810,980	22·57

Not only in quantity, but in quality, does English coal take precedence of all others, albeit certain qualities of Rhenish coal boast a high percentage of carbon. The analyses of Grundmann and Riley assign to Dowlais coal 89·33 per cent. of carbon and 1·20 of ash, and but few of the best qualities of English coal contain less than 80 per cent. of carbon or more than 3 per cent. of ash. The ash varies, of course, widely—the best Newcastle coal, containing 1·73 of ash to 84·31 of carbon, while Boghead has 24·23 of ash to 61·04 of carbon; but this latter is peculiar coal, especially valuable for its gaseous contents. Spanish coals contain a low proportion of carbon, ranging from 45·5 to 82·0, and Russian coal appears from chemical analysis to be of poor quality—often containing as much as 17·1 per cent. of ash to 38·7 of carbon. Rhenish coal, although containing more ash than English coal, may be pronounced as pretty uniformly good. Analyses of the coal of the Ruhr basin show about an average of 80 per cent. of carbon to some 5 per cent. of ash. Ibbenbüren, Osnabrück, and Minden districts, also produce coal of great carbonic strength, but allied with 8 or 9 per cent. of ash. One sample from the Piesberg pit on the Lechtingen seam, near Osnabrück, is reported as containing 91·141 of carbon to 6·087 of ash. *From the Official Report of the Sections of the Vienna Exhibition.*

Improved Fuel for Blast-Furnaces.—A mixture of lime and peat, highly compressed by hydraulic power into brick-shaped masses and then dried, has been proposed as a fuel for iron-smelting wherein the pure fuel and the required flux are simultaneously supplied—moreover, such bricks would be more easy to dry than compressed peat alone. *Iron, No.* 79, *p.* 72.

Naphthalene.—J. HERZOG states that naphthalene comes over late in the distillation of coal tar. It is a solid at ordinary temperatures, and when pure forms large colourless crystalline plates; it has a faint, peculiar odour; is unctuous to the touch, and evaporates slowly at the common temperature of the air. Naphthalene is not absorbed by water, but it is by the volatile and fixed oils, and by naphtha and coal tar; hence the advantage of keeping the raw gas, until it is thoroughly cooled, in contact with tar and ammoniacal liquor, in a long hydraulic main.

Richer qualities of gas containing much hydrocarbon do not deposit naphthalene, and hence the use of naphtha as a remedy for naphthalene in the mains and service pipes. Naphthalene is not easily decomposed by heat; it is quickly deposited by cold, forming brilliant white scales, which have a tendency to collect in the bends of pipes, and wherever there is an impediment to the easy flow of the gas.

For the gas engineer it seems most important to prevent the crystallization of naphthalene, and this it appears can be done by keeping the gas containing naphthalene in contact with the light volatile oils; though all the chemical properties of naphthalene are not yet discovered, it is a well-known fact that naphthalene shows a great affinity for light hydrocarbons. In gas generated at a low temperature, many of the volatile substances are lost in an unaltered condition, with the tar in the hydraulic main and connecting pipes, in their liquid form, and combine with, or rather, take up, the naphthalene. Under an increased heat the greater part of these oils would form fixed gas, and consequently increase the volume of the gas manufactured. Though it is a great advantage to make use of as great a quantity of these lighter oils as possible in distilling the same to gas, we all know that all the lighter oils cannot be used up entirely in the distillation of coal, and thus it seems the duty of an enlightened gas engineer not to waste the same, but to make a judicious use of them by keeping the gas as long as possible in contact with gaseous vapours, and thus preventing the crystallization of the naphthalene which is contained in the gas. The lighter oils as long as they are united will, whenever they settle down in a condensed state, carry away a great deal of naphthalene in a liquid form, and the naphthalene will, in a pipe placed in proper descent, be carried into the drips. The lighter oil vapours will separate from the gas at a low temperature; in condensing, therefore, it is thought by many best that the take-off pipes from the hydraulic main should be nearly on a level with the same, and should be of sufficient length. Clegg gives as a rule that for every inch of diameter, the take-off pipe should have a length of 10 ft., the working pressure being 2 in.; for instance, the take-off pipe being 10 in. in diameter, the proper length would be 100 ft. By increased working pressure they will of course require increased length in the ratio of their square roots; but even at this rate a great deal of the lighter oils will be lost by condensation.

The author has found in his own experience that these oils, if collected in a little tank and revapourized, will greatly diminish the tendency of the naphthalene to crystallize, and at the same time improve the quality of the gas. The form of such an apparatus should be a small iron tank, closed at the top, and placed below the level of inlet pipe of the condenser, to which all drip water, and with it the lighter oils, must be conducted; the lighter oils will, from the nature of their specific gravity, float on the top of the tank. By passing a coil of steam-pipes through the tank the lighter oils will be vapourized, and the naphthalene will settle at the bottom, and from there can, from time to time, be let off. If there be an insufficient amount of these lighter oils, some benzine, benzole, or naphtha can be added with advantage, particularly if coal be used containing only a small proportion of these lighter oils. Hydrocarbon vapours will surely liquefy naphthalene in any pipe or vessel.

A further tendency of naphthalene to crystallize will be created if gas containing naphthalene is passed in from a hot to a cold place; say, for instance, if the gas be stored in the holder, and the same, without a building, is exposed to a heat of a high temperature; when let into pipes in the ground which are located in a lower temperature, naphthalene will surely crystallize, and in course of time will stop up the pipes more or less; or if the street mains are, in certain locations, laid too near the surface of the ground, and afterwards the gas be passed into pipes located in lower ground, by which a variation of temperature is created, naphthalene will have a tendency to crystallize. *Paper read before the Gas Light Association of the United States. Cleveland Meeting.*

G. HYDE states that the crystallization of naphthalene in the mains and pipes is greatly accelerated by the employment of high temperatures in the gas benches, and the amount is increased by rapidly cooling the gas in contact with cold water or other rapid cooling agents; slack developes more than lump coal. As remedies, the use of a little cannel coal along with the ordinary bituminous varieties, moderate heats with slow cooling, and, if necessary, the introduction of a little naphtha into the inlet and outlet pipes so as to charge the gas with vapour of liquid hydrocarbons, are to be recommended.

WHITE states that the agency of high temperature in accelerating the deposition of naphthalene lies in the fact, that at high temperatures less volatile liquid hydrocarbons are formed, but more gas; the presence of the vapours of such bodies in the gas caused the naphthalene either not to deposit at all, or to deposit as a liquid. *Ibid.*

Petroleum Oil.—Good petroleum should be colourless or light yellow, and possessed of no unpleasant odour; at 15° it should have a sp. gr. not exceeding 0·804, and not under 0·795. When shaken with a sulphuric acid diluted with its own bulk of water it should only colour the acid a light yellow, becoming itself lighter in colour by the treatment. At 34° it should not burn when a light is applied. *Dingler's Polytech. Journal, ccxi.* 76.

Distress Light at Sea.—N. HOLMES patents the use of calcium phosphide for the production of a brilliant light as a danger signal at sea; phosphorus and chalk are heated together to a white heat; when brought in contact with water spontaneously inflammable phosphoretted hydrogen is evolved, whilst the material itself is incombustible, and is perfectly safe for carriage. To utilise this for marine purposes the material is hermetically sealed in a conical tin case with a copper exit for the flame at the top, an entrance for the water at the bottom, and a tip of soft metal at the top and bottom of the cone. This conical case contains a perforated tube running down to the cone point, and closed by a soft metal tip. The inflammable phosphide of calcium is ranged all round this tube, and the whole apparatus will float like a buoy on water. To bring it into use, the soft metal tips are cut away with a knife which a sailor is never without, the case is thrown into the sea, the water ascends into the perforated tube, causes the phosphide of calcium to inflame, and the composition contained in a small case, say 4 inches by 6 inches, will give a fierce light for three-quarters of an hour, and will burn for about two hours. *Iron, No.* 84, *p.* 229.

§ 6. *Miscellaneous.*

Explosives.—A. P. BLAKE proposes the use of an explosive compound consisting of nitro-glycerine washed with water, and a solution of silicate of soda, and mixed with other substances to dilute and modify its action. The substances used in place of infusorial earth are the scales of fresh-water fish mixed with carbonate of soda, and nitrate of soda, well-burned, ground, and sifted. Nitrate of soda, manganese, double carbonate of soda, and prepared sawdust are mixed with a solution of resin and spirits of wine. The mixture is mixed in a damp state with the prepared infusorial earth. After the second mixture is prepared, a third is made by sprinkling that already obtained with a solution of sulphur or bicarbonate of sulphur, and then by adding finely-ground burned bones or coal. This mixture is then further manipulated in other rooms. First, it is mixed with bran and prepared sawdust, which are saturated with nitro-glycerine. This is repeated with the hand until the requisite quantity of nitro-glycerine is absorbed. The explosive is formed into cartridges and carefully packed. Other modifications of this preparation are also made up and employed. *Iron, No.* 80, *p.* 102.

Spontaneous Falling of Elm Branches.—It not unfrequently occurs that branches perfectly covered with foliage, and apparently quite sound, suddenly become detached from elm trees, the falling of such boughs being only previously indicated by a few cracks; an occurrence of this kind recently took place in Kensington Gardens, nearly occasioning serious injury to many persons beneath the tree. It is stated that the Queen once narrowly escaped a similar accident. The hot summer months appear to be the period when the boughs are most liable to drop, probably because they are then most densely covered with verdure.

Manufacture of Dicarbon Hexachloride (sesquichloride of carbon).—A. E. DAMOISEAU patents the following process. A mixture in the required proportions of chlorine and hydrocarbon gases is passed through granulated boneblack (previously freed from calcareous matters), charcoal, pumicestone, or other porous material in a tube of platinum or other suitable material, heated to the proper temperature. The action of light is, therefore, rendered unnecessary. *Chem. News, xxx.* 122.

Preparation of Aldehyde.—Aldehyde for the manufacture of aldehyde green is obtained as a bye-product in the preparation of lead acetate by means of ozonized air. *Dingler's Polytech. Journal, ccxi.* 76.

Cement Bricks.—Messrs. BODMER prepare bricks of various qualities, without burning, by intimately mixing certain materials of the nature of cements or mortars, and squeezing the mixture into the desired shape by hydraulic pressure in a specially constructed machine. Sand and selenitic lime are the constituents of one kind of brick; these substances, together with Portland

cement, of another; a very serviceable kind of brick is prepared from blast-furnace slag, which, consisting chiefly of silicates, decomposible by lime, is just as serviceable for this purpose as the volcanic products trass and puzzolana, which have long been employed. All three materials are analogous both in the method of their formation and their composition. The following analyses illustrate this :—

	Blast-furnace Slag.				Trass.	Puzzolana.
	Cleveland District.		Wales.			
Silica . . .	40·75	34·00	49·50	45·00	65·0	44·5
Alumina . .	24·47	24·33	15·20	16·42	7·0	15·0
Lime . . .	24·50	34·00	19·70	26 78	2·6	8·8
Magnesia . .	7·17	5·88	3·00	0·40	1·0	4·7
Oxides of iron, manganese, &c.	2·05	0·07	8·22	10·84	5·0	12·0
Potash . . .	—	—	—	0·46	7·0	1·4
Soda . . .	—	—	—	—	1·0	4·1
Sulphur . .	0·65	1·72	1·29	—	—	—
Water . . .	—	—	—	—	10·6	9·2

The practical difficulties in the way of disintegration and grinding have been overcome, the former by the employment of differential rollers. Slag cement compares favourably with Portland; a mixture of seven parts slag with one part lime (by weight) showed a tensile strength of 271·2 lb. per square inch fourteen days after gauging, and a month after showed 470 lb. The ingredients of this cement are intimately mixed automatically, and then ground, the cost of the operation being about 3*s.* per ton.

The bricks give a good result on application of the usual tests. They have a good sound "ring," are very hard, and can be made of various shades of colour, or even enamelled, we should imagine, by a little ingenuity. The following table embodies the result of a series of experiments designed to determine the degree of absorption of various bricks. They were first dried on a heated iron plate and weighed. After fifty hours' immersion in water, they were weighed a second time.

	Ordinary Bricks.		Bodmer's Bricks.		
	Best Gault Clay.	Best Stock Clay.	Sand and Lime.	Blast furnace Slag and Lime.	
				Dry Slag.	Spongy Slag.
	lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.
Weight dry . .	5 15	4 13	6 9½	7 7½	5 7½
Weight wet . .	7 2¼	5 14½	7 1½	7 12¼	5 14¾
Water taken up per brick . . .	1 3¼	1 1½	0 7½	0 4¾	0 6¾
Percentage of absorption . . .	20·26	22·72	7·09	3·97	7·69

The process of brick-making by the machine is simple. Hoppers are filled by hand with the materials employed, each into its separate hopper. From this point to the removal of the finished bricks all operations are automatic. Measured portions of each ingredient are caused to fall upon a travelling belt which delivers the mixture into an apparatus, in which it is thoroughly incorporated, and from which it is deposited upon a second travelling belt, which carries it to the press, where measured quantities are delivered into the moulds. The press is hydraulic, consisting of a circular table revolving horizontally, and of course stopping when pressure is applied. The table contains six pairs of moulds, making, therefore, one-sixth of a revolution between the stoppages for application of pressure. Two pairs of moulds are subject to pressure at once, two other pairs being automatically filled, and the bricks rising out of the remaining two pairs simultaneously. The bricks are removed by hand to barrows, and conveyed to the yard, where they are left to ripen. The time required for this varies according to the quality of the lime used, and also according to the weather, from one to two months, but the hardening goes on for years. Seven strokes per minute are made by the press, giving in that time twenty-eight bricks, or about 80,000 per week, as the result of the labour of two men and four boys, exclusive of wheelers and pilers. When sand is used, from one-sixth to one-eighth of lime is necessary, but with slag, as little as one-sixteenth of its weight of lime may be employed to produce a good quality of building brick, weighing about 58 cwt. per thousand. The cost in wages varies from 3*s.* to 3*s.* 6*d.* per thousand. *Iron, No.* 79, *p.* 72.

MICA.

THIS mineral is sometimes erroneously called "isinglass," "Muscovy glass," &c. Its name signifies to shine, to glitter, from this conspicuous characteristic which it possesses; it is of common occurrence in primary and secondary formations; is one of the chief constituents of granite, mica schist, and to a small extent gneiss. In limestone it forms masses, pockets, beds, and veins, often of considerable size. In granite the plates or crystals are small, mostly under an inch in diameter, though in some coarse granitic formations a foot and upwards. In Siberia plates have been met with as much as 5 ft. and 7 ft. across.

The group of micas may be classified in two divisions. Those which are silicates of alumina and alkalines, as muscovite, lepidolite, and the magnesian micas, as phlogopite, biotite, &c. All are readily distinguishable for their brilliant lustre or glitter, whence the name, as well as for their distinct cleavage in one direction, and tough foliaceous structure, which permits of separation into very thin sheets. The two species described below are very valuable in commerce. Muscovite is essentially a silicate of alumina and potash, with occasionally a small and varying quantity of iron, traces of fluorine, and in some of the green varieties chromium; crystallization, trimetric, usually six-sided tables; colour, black, brown, silvery white, grey, green, with pearly, pseudo metallic lustre; not attacked by acids; refractory, only fusing on thin edges before the blow-pipe; lamine very tough and flexible.

Phlogopite: Magnesian mica; composition silica, alumina, and magnesia, with traces of iron, potash, with soda and fluorine; crystallization similar to the foregoing: colour, brown, reddish-brown, yellowish-brown, olive-green, grey with pearly lustre: whitens in blow-pipe flame and melts on thin edges; when reduced to a fine powder, attacked by hot sulphuric acid, the silica separating in thin scales; also like muscovite, so tough and elastic that it can be split into sheets of extreme tenuity. This species is mostly found in limestone.

The early history of mica and its uses are obscure. But the researches of Professor Kerr in North Carolina have brought to light very ancient, and probably the remains of the most extensive, mica mines that are known in any country. These operations were invariably in ledges of coarse granite, which contain nothing but patches of mica. The size and number of these mines are said to be remarkable; some of the open-cuts are 100 ft. in diameter and 80 ft. deep. Tunnels also of considerable length exist, though too small to permit an ordinary-sized man to work in, but showing distinct marks of a chisel-shaped tool about an inch in breadth in the granite wall. A quantity of mica plates have been found in these works; some, trimmed to particular shapes, have led to the conjecture that the uses to which it was applied were for windows, mirrors, ornaments, &c. The magnitude of the operations excites surprise, and shows that a large demand must have then existed.

In more modern times the use of mica was chiefly for windows of war ships, lanterns, and other conditions liable to concussion; but recently it has been applied to a variety of useful purposes, and has acquired a very considerable value, so that in times of scarcity good qualities have sold as high as 10 dols., 15 dols., and even more per pound. The value of mica is determined by the colour, size, soundness, and toughness; the most transparent large sound sheets being in highest esteem. The chief consumption at present is for stove glass. Without mica we should lack the cosy ruddy genial glow of the base burning and other illuminated stoves. The quantity consumed annually in this branch it is difficult to ascertain, but it is necessarily very large. Coarsely pulverized, it is found to be an excellent roofing material (far superior to ordinary gravel), to which use it is also applied in the same manner as slate. It makes, when finely ground, a good lubricant for certain purposes. It is superior to cardboard for marine compass dials. Formerly it was largely used as a filling for fire-proof safes. It is also used in the lettering of fancy signs. When very clear it forms a better protection to photographs than enamel. But by far the most artistic application is in the manufacture of lamp shades. With the aid of chromo-lithography exquisite pictures are printed on sheets of mica, three or four of which are tastefully joined together, and form a really beautiful design. Mica is eagerly sought for to supply the large and increasing demand. Active operations are carried on in various places, particularly in North Carolina, New Jersey, &c.; also in several places in Canada.—*Paint and Oil Trade.*

WET WEATHER HARVESTING.

NATURE has been very bountiful to England in the matter of minerals, such as coal and ironstone, and her soil also is fertile; but against these advantages must be placed a proverbially uncertain climate, so uncertain that until the harvest is actually in the stackyard, the best judgments as to its ultimate value are usually at fault. No foresight can effectually guard against the malign influences which militate against tillage farming in the British Isles; and, consequently, while, on the one hand, agriculture is one of the most important, it is also, on the other, one of the most—as regards results—uncertain pursuits that can be engaged in. It seems somewhat remarkable that in the presence of a persistently wet climate, so little attempt has been made to supplement the heat of the sun, with artificial means by which to, at least, mitigate a national evil. The appliances of which we give illustrations consist partly of contrivances used abroad to expedite and facilitate the drying of corn and hay in bad weather, and partly of certain mechanism devised by a gentleman in this

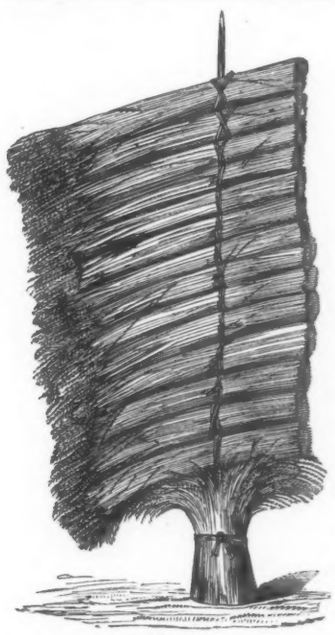


Fig. 1.

country, who has devoted much time, money, and thought to the subject—a subject whose importance can best be appreciated by noticing the fact that the estimated loss to the kingdom, due to a wet harvest, amounts to a sum ranging from £10,000,000 to £20,000,000 sterling. This loss is enhanced in its ill effects by the fact that it represents a heavy and burdensome tax upon the native bread-stuffs of the country, and in an indirect way acts injuriously upon the meat production by reducing the quantity of food available for stock. An estimate made a very few years ago showed that of the fifty-seven million statute acres of land in Great Britain, rather more than half was under cultivation. Of this, about one-third was devoted to raising cereal and leguminous crops. The yield in bushels of dressed corn per acre of these nine millions of acres differs in the proportion of about six to one. Twelve bushels is a not uncommon yield from neglected, unmanured lands, while highly-cultivated lands constantly give a return of even fifty-five bushels per acre, and a difference—not an impossible one—of £15 per acre, equalling a difference of forty-three bushels at 7*s.* per bushel over half of the nine millions of acres, gives an amount closely approaching the entire State expenditure for a twelvemonth. True, this loss is not in its total of such great magnitude directly, but it becomes so by its reactionary influence on the live stock of the country.

In the presence of such a state of things, it is natural that the attention of agriculturists should be directed to some remedy, and before examining what has been done at home, attention may be given to what has been and still is done abroad. Necessarily the means and materials at hand will, to a great extent, be found to regulate the steps taken to devise artificial methods of drying or facilitating the drying of corn. Foremost on the continent of Europe stands Sweden. The abundance of wood there is turned to account, and out of the thinnings of her great forests different arrangements are made for at least partially protecting cereals from the evils of a bad climate. All the contrivances are based on the principle of exposing as little surface of crop to rain and as much to air currents as possible. One plan for this is illustrated at fig. 1, which shows a wooden stake driven into the ground, a common fir pole about 5 ft. long, and sunk about a foot into the earth; then one sheaf is slid down on this in an upright position, and above it a series of sheaves are placed horizontally, as many as four or five. The sketch shows a larger number, but assuming a sheaf to be a foot in diameter, evidently not more than the number stated above could be placed on a four-foot pole, even with squeezing. Another arrangement is a rack, made of a pair of hurdles, on which the

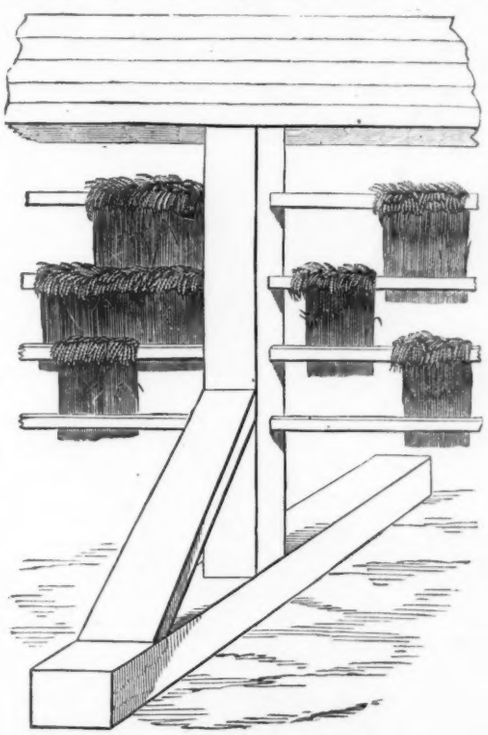


Fig. 2.

sheaves are hung. An elaborate arrangement of similar nature is shown at fig. 2, in which a regular frame is made and covered with a sort of shed roof, and the sheaves are hung on the bars. In either of these plans, it is evident that the air has free circulation through the sheaves, while at the same time, as regards rain, the upper sheaves form some kind of protection for the grain in those beneath. However well such schemes may answer in thickly-wooded countries like Russia or Sweden, they are not well applicable to this country. In the great Russian corn-producing provinces of Courland, Livonia, and Lithuania, it is a usual and long-established practice to dry the grain crops in a kind of wooden shed, which, by a few cheap, rough additions, is made to do duty as a kiln, such a kiln being considered an important adjunct to a homestead. Fig. 3 shows the general arrangement of a thing of the kind. It will be seen to consist of, as stated above, a rough shed, covering in a floor raised some feet from the ground, and beneath the floor, at one end, is a fire-place, on which a fire is kindled, the hot air from which ascends through the interstices of the floor, and evaporates the moisture from the wet corn and straw. The fire is of wood, and is kindled first, and allowed to burn out to embers before the sheaves are placed on the floor; and it is found in practical working that no injury is done to the germinating

power of the seed by this kind of desiccation, which usually occupies about twelve hours; while on the other hand, for general purposes, both the grain and the straw are improved in quality, and both can be stored in barn or stack without fear of heating or of mildew. Such a method is inapplicable in this country, because, for one thing, the scarcity of timber is an obstacle, and as to coal or coke, they must have special contrivances for burning them, not needed with charcoal embers, while also the thing is only applicable on a small scale; and it was the being impressed, on the one hand, with the great need existing for some good means of harvesting cereals and hay, and, on the other, with the impracticability of rendering any of the foreign schemes available in this country, that prompted Mr. Gibbs to devote his attention to the subject, and to labour to evolve some practical method of supplementing the few sunny hours present in an English harvest for the desiccation of corn and grass crops by artificial contrivances of such a nature as would suit the conditions of working in this country.

In the first place he devoted attention to the determination by experiment of whether or not artificial heat could be employed without injury to the germinating power of the grain, or in any respect injuring or deteriorating the quality of things subjected to it. Mr. Gibbs, in an essay he wrote on this subject of artificial harvesting, says he tried the following experiment on grass: he cut up a carefully varied selection of grasses into half-inch lengths, weighed 100 grains of them, and dried them on a sheet of letter paper; when dried the weight of hay was 20 grains, the drying was carried too far, however, as the best hay contains perhaps 20 per cent. of moisture. After numerous experiments and much calculation, he decided on trying a common malt kiln as a drying stove, and sent a load of rowen that had been lying out under all weathers for about three weeks, down to a friend's malt kiln, and the reeking wet, sodden grass was tossed on to the kiln floor, and kept carefully turned and thrown up and shaken, so that in less than half an hour the mass was dried fit for stacking, and so much improved in colour and smell that some of it was eagerly eaten by both horses and cows at the time. The next experiment was made in a saw pit which was lined with iron plates, and a wire netting floor laid down; this acted pretty well, the fire being kindled beneath, but the necessity for the most vigilant attention, as the hay would dry up on the wires, become a mat, and arrest all transmission of heat, was a defect; while every time the hay was tossed up, the hay seed fell through to the fire, so that there was great waste in this respect. The next experiment was to move the fire to one end, to substitute a plate-iron floor for the wire one, and to take a hot air flue from the furnace to a chimney stack some yards off; the great waste of heat rendered this plan abortive. After various other schemes had been tried and found wanting, the following was essayed. A trench 3 ft. deep, as many wide, and 9 ft. long, was dug in the ground; in this was built an arched furnace with a firegrate half way up from

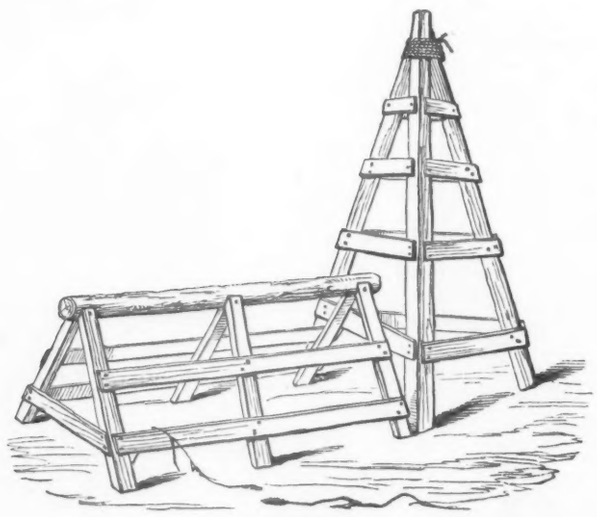


Fig. 6.

the ground; the usual fire door and fittings were placed at the one end, while from the other was led a horizontal flue 12 in. square and 4 ft. long. At the point where the furnace starts from the fire, a thin wall of perforated bricks was built, and at a little distance a perforated iron plate fixed, and beyond this a more finely perforated plate, so that by these screens all cinders or sparks were effectually arrested. At the end of the flue a brick chamber was made, within which was arranged a fan whose axle passed to the outside of the wall, and here a belt pulley was affixed. Passages from the hot air flue communicated with the sides of the fan. Upon the chamber thus fitted was erected a wooden shaft or chimney, about 2 ft. square and 20 ft. high; 4 ft. from the ground an opening was made, and at this point and near the top of the chimney respectively, an axle and drum was placed, while over both, and uniting them, was fitted a broad band of strong canvas or sailcloth; to this band was affixed bars having prongs or tines similar to those of a hay tedder. On the machine being set in motion, the fan drew a strong current of air through the furnace and blew it up the chimney very highly heated. Wet grass thrown in at the opening in the chimney near the ground, was carried up by the tires and belt and then turned over the top, and came tumbling and shaking down through the descending tines, every part being thoroughly exposed to the influence of the hot air. A delivery door was made opposite to the top drum, and when the hay was dry enough the speed was increased, and the centrifugal force threw the hay off to a platform, whence it was forked to the stack. Mr. Gibbs then examined the cost of working, and he says that he found that sap was taken from the grass by the mere withering process equally well in wet as in dry weather, and consequently all that artificial drying has to do is to evaporate rain or dew moisture. One ton of very wet hay has about from 5 cwt. to 15 cwt. of water in combination with it, and to expel this, from 1 cwt. to 3 cwt. of coke is necessary; taking coke at 1*s.* 6*d.* per cwt., the artificial drying would pay well, because damaged hay does not command at all so good a price as that which is well saved, the difference in price representing much more than the charges for drying by artificial means. In view of the cost to construct and maintain an apparatus like that just described, however, the inventor next essayed to dry hay or grass by simply exposing it in a wooden trough to a current of hot air. Experiment showed that by this method 25 lbs. of half-made hay lost 10 lbs. in 15 minutes, the temperature of the ingoing air being 250° to 280°; the hay so finished was fragrant, of good colour, and eagerly eaten by every kind of stock. The next experiment was to take 21 lbs. of this dried hay and drench it with water, of which it retained 11¼ lbs., making its total weight 32¼ lbs.; it was then subjected to the hot blast, and in 11 minutes was reduced to 16 lbs., and had lost much of its fragrance. This experiment is noticeable from the fact that it demonstrates the serious loss caused by alternately drying and wetting hay, as it is so often by alternations of weather. Practical farmers know well that the loss of weight caused by the dissolving away of the soluble and most nutritious parts of the hay by repeated wettings, equals 20 per cent. of the whole. The next experiment was made with hay two days cut and nearly fit for stacking, and 30

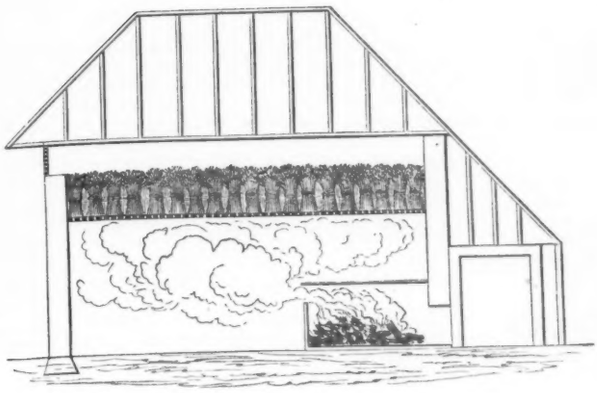


Fig. 3.

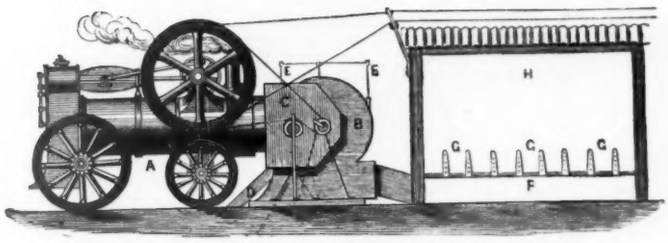


Fig. 4.

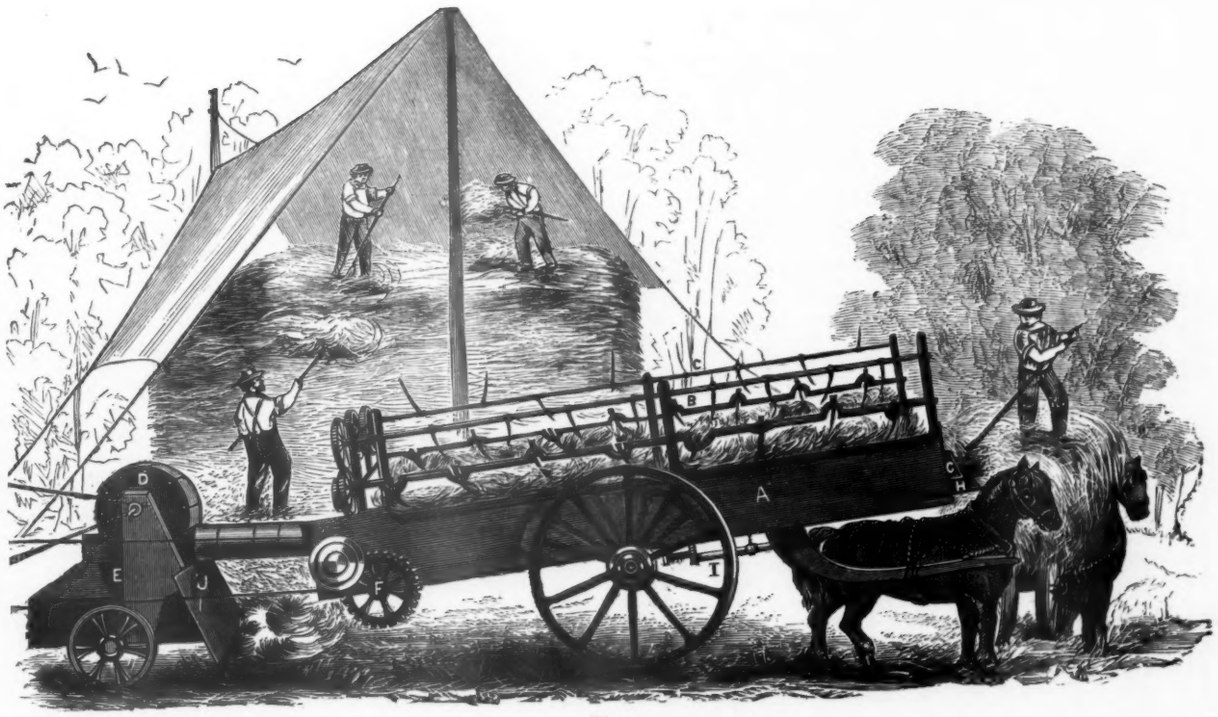


Fig. 5.

WET WEATHER HARVESTING.

lbs. of this was reduced to 22 lbs. in four minutes by a blast whose temperature was 320°. As regards the influence of artificial drying on sewage grass, 45 lbs. of it saturated with morning dew was dried into 9 lbs. of green and fragrant hay in 15 minutes, under a blast of 320° air.

The following experiment was carried out in presence of the Duke of Sutherland, the Marquess of Kildare, Lord Blantyre, Sir T. F. Buxton, and several other gentlemen. A quantity of grass upon which four hours' rain had fallen, was cut and brought at once to the wheat-drying shed, and the grass was simply thrown on the ground before the hot blast, lifted and shaken out by two men, and converted into green hay in seven minutes, the temperature of the ingoing air being 300° to 320°. The inventor now reached the stage of adapting a fan to an ordinary portable engine and drawing the hot air from the smoke-box. As regarded the work thrown upon the engine to drive the fan the pressure of air used was 5 lbs. to the square inch, and the temperature was 320° with furnace door closed, and 220° with it open. The principle of the arrangement is simple enough; a common fan is placed immediately in front of the smoke-box of an ordinary portable engine, the fan being actuated by means of a belt from the fly-wheel of the former; the air is sucked by the fan from the smoke-box and driven through a pipe, either beneath a barn floor studded with short vertical nozzles perforated all over with small holes (see fig. 4), or applied in some other way best calculated to distribute the air thoroughly throughout the hay, or else, if need be, the sheaves of corn. As regards the cost of the thing, the inventor says that according to experiments made in 1866, the cost equalled about 3*s.* 6*d.* per ton, this including all the charges for drying the most completely soaked grass; while as regarded partly dried hay, the cost per ton has been found to be but about 2*s.*

Experiments were made in 1870, before Lord Kinnaird, Sir John Ogilvie, Bart., M.P., the Honourable Mr. Fitzwilliam, M.P., Mr. Mechi, Professor Imray, and many other noblemen and gentlemen, and hay dried by hot air in these experiments was analyzed by Professor Voelcker, who found that the hay contained 5 per cent. less moisture than undried hay; while the farmers present pronounced it better in quality, fragrance, and colour than the best sun-dried hay.

As regards the application of this thing to the Netherlands, the lowlands there are well adapted for the production of grass in many of the districts; but as regards the hay harvest the variable nature of the climate militates greatly against its operations. When drought prevails during the summer, the harvest is kept back till late in the autumn, when the weather is broken and the sun's power feeble, and consequently the successful application of artificial means of drying is of great importance; and there certainly seem no more reasons against drying hay artificially than there are against drying hops.

Ever since 1866 the inventor has been working and experimenting with a view to simplifying the appliances for attaining his object, and we illustrate on the foregoing page his latest machine (fig. 5), it embodies the following features: viz., a trough with a reciprocating floor, on which the wet grass is placed, and which is so arranged that it can be mounted on wheels, two sets of revolving tines are fitted, one at either side of the trough, and which being actuated by gearing driven by the same motor as that which propels the fan, shakes and stirs up the grass. A fan, D, so arranged that it sucks air in through a stove attached to the apparatus and drives it heated beneath the reciprocating floor of the trough, heating it up to the requisite temperature; the reciprocatory movement of the trough floor shifts the grass fed in at the higher end from the cart to the lower end, whence it is forked on to the stack. The tines are arranged to hinge loosely on the cranks in the rotating axles to which they are fitted, and each tine has a tail-piece which, as the crank shaft rotates, engages in a stud on a fixed bar behind the former, and as the cranks raise and lower the tines their tail pieces engage into the projections, and then depress the tails and raise the tines, so that the combined action tosses the grass up and down in the trough most effectually; while to increase this action the bar, instead of being fixed can be made itself to rotate, thus increasing the movement of the tines, and consequently their tedding action. The letters explain the machine very clearly. A is the trough, 20 ft. long by 6 ft. wide; B, crank-shaft carrying tedding-out tines; C', cam-shaft carrying adjustable cams for engaging in the tail pieces of the tines; D, fan for the hot air; E, portable stove for heating the air, with outer casing for preventing radiation; F, spur wheel acting on a crank shaft to actuate reciprocating floor; G, inner air-duct attached to floor and sliding within outer air-duct, which is not shown; H, projecting platform formed by one end of the reciprocating floor upon which the hay is thrown from the carts; I, screw-jack for regulating slope of trough.

Fig. 6 shows frames sometimes used on the Continent to secure ventilation of the stacks; the vertical frame is placed in the centre of the base of the stack, and the other passes from it to the outside, so that air has free admission.

CASTINGS.—A means highly recommended for obtaining very smooth castings is mixing with the green foundry sand forming the mould about one-twentieth part of tar, a mixture which is employed without the addition of any other substance.—*La Métallurgie.*

FARMING IN HOLLAND.

WILHELMINADORF, GOES, HOLLAND.

WE give in the following columns a picture of what is probably one of the example farms of Europe. It appeared originally in the Bath and West of England Agricultural Society's "Journal."

"We have here in our Wilhelmina Polder, province of Zeeland, in Holland, about 2,990 acres in regular cultivation; the rest is wood, pasture, &c. Of this, 2,825 are of a clayey description, some heavy clay, but never so stiff as in some parts of England, and always a sandy subsoil at various depths. About 150 acres are sandy and poor altogether (old sandbanks on which no alluvial clay was deposited). There are six farms and on each 14 work-horses, with one old one for extra use, making 90; besides about 20 young horses, as we rear them ourselves. During part of the year 18 pairs, or 36 hired horses, are also employed. There are on each farm five ploughmen, young and unmarried men; they live with the bailiff, and get, besides their food and board—the first ploughman, £12; the second, £9 6*s.* 8*d.*; the third £8 16*s.* 8*d*; the fourth, £6 13*s.* 4*d.*; and the fifth £5 5*s.* They are hired for nine months, from March to December. Generally the horse-work goes on till the middle of December. During winter till March, or till the end of February there is nothing to do but some carrying of corn, of straw and such like. Besides the five ploughmen living on the farm, there are during nine months or less two labourers for the remaining two teams (each man works here generally two horses in a team, also in carrying, for which light waggons are used). For rolling, mostly one horse is used; also one horse for light harrowing. In winter, there remain two or three ploughmen on each farm, for taking care of horses and cattle. For this they get 36*s.* on each farm, besides food and board. The labourers (not hired ploughmen) get 8*s.* 4*d.* in the week and nothing else. Sometimes boys are employed, chiefly in spring, to work the horse for extra use; they receive 1*s.* per day without food. Other labourers working the horses, December and in winter, get 1*s.* 3d. per day. Sometimes in summer in fallow-work, or during November, two ploughmen will work with three horses each, for deep ploughing; then sometimes we can spare one of the two aforesaid labourers.

"The food of our horses is as follows:—During about two and a half months in winter, when they do not work, different kinds of straw, chiefly of beans and oats, and a little bit of hay. When they begin to work, a little more hay, besides 11 bushels of beans and 11 bushels of oats per week, for the 14 horses on each farm. In May this food is gradually stopped as they go to pasture.

"In June, July, August, till mid-September, they receive during the day, cut red clover, whilst they are always in pasture at night. And besides this, they receive on each farm in summer 70 bushels of beans and oats altogether. At middle of September feeding of carrots is beginning, and the horses receive, besides, 25 bushels of oats or beans per week on each farm. In October, they do not go to pasture any longer; instead they get a little hay, if possible, and the allowance of carrots is increased to ¾ cwt. per horse, per day, and oats the same as before. November the same as October. In December, the feeding of oats and carrots is gradually stopped and again changed to different kinds of straw. The carrots are always cut or pulped, and mixed with chaff of wheat or cut straw, and given after oats. Horse-work is severest in autumn, not only for ploughing, but also for carrying madder and roots.

Young horses get, till they are one year old, 1 bushel of oats per week, besides hay and clover in summer. When they get older they do not get oats any more, but they go to pasture for the whole summer, and in winter they receive some cut mangolds and hay.

As to the cost of food, it was :—

£12 per horse on an average per year, from 1831-1840.
£9 16*s.* " " " 1841-1850.
£9 8*s.* 2*d.* " " " 1850-1860.

From 1831 to 1840 more beans and oats were given than the quantities mentioned. So during the last twenty years the cost of food was about £10 per horse. In your country it is at least twice as much. All is taken into account except the straw, as when the horses have taken the best of it it is partly used as litter.

Now as to other expenses, I can give you the following account, being the annual average of ten years :—

Wages and food of the men working the horses				£730	2 0
Farrier and drugs				14	19 9
Shoer				15	14 0
Mending implements, purchase of implements, and harness-makers, &c.				370	11 10
Cost of food of the horses				1079	12 5
				£2211	0 0
Purchase of horses (sometimes still necessary)	£33	15	9		
Value of horses at the beginning of the year	1168	7	0		
	1202	2	9		
Sold old horses £14 1 8					
Value at the end of the year 1162 18 4					
	1177	0	0		
				25	2 9
Total				2236	2 9
Value of the work done by the horses				2395	1 9
Profit				158	19 0

This profit is realized notwithstanding that, for ploughing, the horses are credited with only 4*s.* per acre ; for ploughing with three horses, only 5*s.* 6*d.* per acre is placed to their account ; for harrowing about 1*s.* 6*d.* per acre ; light harrowing about 11*d.* per acre ; rolling, 8*d.* to 11*d.* per acre ; carrying crops in harvest time, 4*s.* 8*d.* per acre ; carrying madder, roots, and corn, &c., 6*s.* 8*d.* per day, in winter 5*s.* per day. We hire men with horses and implements for these prices.

"Now to the questions about the doings of the horses during the course of the year. The 2,825 acres of clayey soil are cultivated according to the following rotation :—1st year, peas ; 2nd, wheat ; 3rd, mangolds, dunged with 10 tons farmyard-manure, and 2 cwt. guano and bones per acre ; 4th, beans, dunged with 16 tons of manure per acre ; 5th, wheat ; 6th, oats, with clover and grass ; 7th, clover ; 8th, fallow, dunged on some lands with 14 tons of manure per acre ; 9th, winter barley, the stubbles with 20 tons manure per acre ; 10th, madder ; 11th, madder ; 12th, madder, dug when 2¼ years old ; 13th, peas ; 14th, wheat, with clover ; 15th, clover ; 16th, oats ; 17th, mangolds, turnips, potatoes, and carrots, dunged as the 3rd year ; 18th, beans, dunged as the 4th year ; 19th, wheat, with clover and grass seeds ; 20th, pasture : 21st, pasture.

"You see every year of each crop we have 135 acres, or 22 or 23 acres on each farm per annum. The 150 acres of sandy soil have the following system of cropping :—1, turnips ; 2, chevalier barley ; 3, clover ; 4, rye ; 5, potatoes ; 6, beans ; 7, rye : turnips, potatoes, and beans are manured. The depth of ploughings (we have the improved American Eagle ploughs) varies from 2½ to 6 inches with 2 horses, and from 8 to 12 inches with 3 horses.

"Now to the number of ploughings, harrowings, and rollings each crop receives. The pasture, in the autum of the 21st year, is broken with 2 ploughings, the 2nd following the 1st in the same furrow, at a depth of 8 inches. 1st year : in spring, harrowing, drilling of peas, 1 light harrowing, and 1 rolling ; ploughing of stubbles, 1 harrowing, 1 ploughing or cultivating, 2 harrowings, 1 ploughing, 1 harrowing, drilling of wheat, 1 harrowing (sometimes we have no opportunity for ploughing thrice, then it is done twice). 2nd year : 1 rolling of wheat (then worked with hand rakes—better than harrowing) ; stubbles ploughed, 2 harrowings, 1 ploughing with 3 horses, at 10 inches. 3rd, mangolds : harrowings, sometimes 1 cultivating (Uley cultivator) ; 1 rolling, ploughing of ridges, manuring, splitting the ridges, drilling, 1 rolling ; horse-hoeing during summer ; in autumn 1 ploughing at 6 inches. 4th, beans : harrowing and ploughing in beans and manure, 1 or 2 rollings and harrowings ; ploughing of stubbles, &c., for wheat, the same as the 1st year. 5th, wheat : in spring the same as the 2nd year ; in autumn, 1 ploughing of stubbles, 2 harrowings, 1 ploughing with 2 horses at 6 inches. 6th, oats : harrowing, drilling of oats, 1 harrowing, sometimes 1 rolling, according to circumstances ; light harrowing, with 1 horse, after the small seeds are sown, or else hand-raking. 7th, clover. 8th, fallow : 1 ploughing of clover in the autumn before, or if the clover is needed for sheep in autumn, this is done in spring of the 8th year. Then 2 harrowings in spring ; 1 ploughing at 6 in., 2 harrowings, 1 ploughing with 3 horses, at 8 in. ; 2 harrowings, 1 ploughing with 3 horses, at 10 in. ; 2 harrowings (on light soils ploughing in of manure at 5 in., afterwards 1 ploughing at 10 in., then 1 harrowing and drilling), 1 ploughing at 6 in. ; 1 harrowing and drilling of winter barley, 1 harrowing. 9th, winter barley : 1 rolling and hand-raking, 1 ploughing of stubbles and manure at 5 in., 1 harrowing, and 1 ploughing at 10 in. or 12 in. 10th, madder : in spring, harrowing, cultivating, 2 harrowings, 1 rolling, ploughing of ridges, 1 rolling, and 1 light harrowing before planting the madder ; horse-hoeing during summer and in autumn, covering the ridges with a plough constructed for the purpose. 11th, madder : horse-hoeing and covering. 12th, horse-hoeing, and as in harvesting the madder in autumn the fields are dug with spades at 3 ft., no horse labour is further bestowed upon it. 13th, peas : in spring as the 1st year ; in autumn for wheat, as the 1st and the 4th years. 14th, wheat : in spring the same as the 2nd and 5th year, and hand-raking of clover seed. 15th, clover : in autumn breaking up of clover as the 21st year. 16th, oats : in spring as the 6th year, 1 ploughing of stubbles, 2 harrowings, 1 ploughing at 10 in. 17th, mangolds, turnips, and potatoes : the same as the 3rd year. 18th, beans : the same as the 4th year. 19th, wheat : in spring the same as the 14th year. 20th and 21st, pasture : sometimes rolling of compost. The 150 acres sandy soil are cultivated in a similar manner, but we do not plough deep there. We also grow flax sometimes.

"The weight of manure carried is about 10,000 tons per annum. As to the distance, the farm buildings are situated about in the midst of their 500 acres. The manure is carried from the steadings to the fields. About 300 tons of manure of the 10,000 is bought at Goes ; the distance from there to the fields is various, but often four miles and more. We do not use any quantity of artificial manure. The weight of crops carried to the ricks I am sure I could not tell exactly, it varies so very much. The weight of roots will be 12 to 25 tons per acre ; of madder 7 tons per acre. Roots are carried to the steadings ; madder to the village to the kilns for drying. Average distance of the farm to the village 2 miles. All the corn to be sold is brought from the farms to the boat at the canal of our village ; the distance is 2 miles or more.

"Horses do not carry much hay here, but a good deal of straw to different sheep-yards and cattle-yards. Produce of wheat on an average, 38 bushels per acre ; of winter barley, 70 bushels per acre ; of chevalier and summer barley, 50 bushels per acre ; of oats, 60 bushels per acre ; of rye, 36 bushels per acre ; of beans, 36 bushels per acre ; of peas, 33 bushels per acre.

"The horses during summer are fetched from the pastures early in the morning. They set to work at 3·30 till 8 o'clock. Then they are taken to the stables, where cut clover is given to them. Some of them will do little jobs from 9 to 12 o'clock, as horse-hoeing, fetching of mown-clover, &c. At 1·30 they set to work again till 6 o'clock in the evening, when they are brought back to the pastures. In spring and autumn they begin to work at 5·30 and continue till 10 ; or from dawn till about 11 ; in the afternoon always the same, from 1·30 till 6 o'clock, or till it is getting dark. So generally they work nine hours per day. During harvest, of course they work as long per day as is needed. In winter, when they have nothing to to, they are allowed once or twice a day to run in the yards, behind the stables. They are brushed and cleaned in the forenoon.

"A usual day's work at ploughing will be different. Light ploughing 2 acres ; ploughing at 5 or 6 in. 1¼ acre. Deep ploughing 1 acre per day. Ploughing of ridges 3 acres per day. Harrowing very different ; say 4 acres per day for good harrowing, light harrowing more per day.

"I believe I have now answered all your questions. Perhaps these particulars of a large continental farm may be interesting for English readers. You see our horses do a good deal, and they cost little for food. You will agree with me that steam cultivation, therefore, could not be profitable here."

The reader will agree with us in thinking that the above report does possess great interest for English readers. The following rough estimate is derived from Mr. Van den Bosch's statement of the labour involved in the cultivation of the farm :—

Crops.	Acreage.	Ploughing.		Harrowing.	Cultivating.	Rolling.	Drilling.	Horse-hoeing.	Dung, &c., carted.		Produce, &c., carted.		Tons carried mile.
		Deep.	Ordinary.						Tons.	Miles.	Tons.	Miles.	
		Acres.	Acres.	Acres.	Acres.	Acres.	Acres.	Acres.					
Peas	135	135	270	540	—	270	135	—					
Wheat	135	135	270	1,350	—	135	135	—					
Mangold	135	135	270	1,080	135	135	—	270	10,000	1	4,000	1	14,000
Beans	135	135	135	540	—	270	—	—					
Wheat	135	135	270	1,350	—	135	135	—	—	—	3,000	2	6,000
Oats	135	135	135	540	—	135	135	—					
Clover	135	—	—	135	—	135	—	—					
Fallow	135	270	540	1,215	—	—	—	—					
Winter Barley	135	—	—	270	—	135	135	—					
Madder	135	135	270	540	135	135	—	270					
Madder	135	—	—	—	—	—	—	270					
Madder	135	—	—	—	—	—	—	270					
Peas	135	—	270	540	—	270	135	—					
Wheat	135	135	270	1,350	—	135	135	—					
Clover	135	—	—	135	—	—	—	—					
Oats	135	135	135	540	—	135	135	—					
Mangolds, &c.	135	135	270	1,080	135	135	—	270					
Beans	135	135	135	540	—	270	—	—					
Wheat	135	135	270	1,350	—	135	135	—					
Pasture	135	—	—	—	—	—	—	—					
Pasture	135	—	—	—	—	—	—	—					
Turnips	23	23	46	92	—	23	—	—					
Chevalier barley	23	—	23	92	—	23	23	—					
Clover	23	—	—	23	—	—	—	—					
Rye	23	23	23	92	—	23	23	—					
Potatoes	23	23	23	138	—	23	—	23					
Beans	23	23	23	138	—	23	23	23					
Rye	23	23	23	92	—	23	23	—					
	—	2,055	3,671	13,762	405	2,703	1,307	1,396					20,000
Miles walked per acre	—	8	10	1¼	3	2	2	3	Add for weight of carts going to and fro				20,000
	—	16,040	36,710	17,202	1,215	5,406	2,614	4,188					40,000
Cwts. of draught	—	5	4	3	4	2	3	2					
		80,200	146,840	51,606	4,860	10,812	7,842	8,376	10 per cent. for draught is cwt.				80,000

To these particulars must be added a great deal for casual employment—on so large a farm certainly equal to the labour of six horses throughout the year, or 600 days of a pair, calculated as at ploughing, or about 20,000 cwt. drawn (= lifted) 1 mile. The whole labour of the farm thus amounts to about 410,000 cwt. drawn (= lifted) 1 mile in the year. If the time of labour of the horses be put at 1,800 hours per annum, which is quite as much as it is, considering their long winter's holiday, this corresponds to nearly 2,245,000 lbs. drawn (= lifted) 1 ft. per minute during working hours. Now, besides the 90 horses whose labour contributes to this result, Mr. Van den Bosch tells me that his hired horse labour amounts to about 170 or 180 days of 18 teams, or 36 horses; and this is equal to the addition of at least 30 horses per annum to the power, and about £1,020 annually to the cost of the horse labour of the farm. If, then, this performance be divided among 120 horses instead of 90, it will amount to 18,700 lbs. per horse drawn (= lifted) 1 ft. per minute during work hours—a result curiously near those which have been already reached in the case of English farms. The whole work on this farm being 410,000 cwt. drawn (= lifted) 1 mile per annum, is equal to 164,000 cwt. drawn (= lifted) 2½ miles in that time, or 91 cwt. drawn (= lifted) 2¼ miles per hour during working hours per annum. Now on this farm the cost of horse-labour is £2,236 2*s.* 9*d.* for home management, and £1,020 for hired labour, in all about £3,260, or 35*s.* 6*d.* per hour. The cost of horse labour on this farm thus comes to be about 4*d.* per cwt. drawn (= lifted) 2½ miles in an hour.

This is considerably less than we pay for the same thing in England, though it is by no means certain that Mr. Van den Bosch is right in supposing that steam-power would not be cheaper than horse-power even in Holland. [We add that since the publication of this letter steam-power has been adapted on the Wilhelminadorf Farm, and Mr. Van den Bosch now works a couple of Fowler's engines.]—*Agricultural Gazette.*

THE IRON AND STEEL INSTITUTE AT BARROW IN-FURNESS.

THE Iron and Steel Institute held its sixth annual summer meeting, by special invitation from the mayor, Mr. Jeremiah Smith, and other influential capitalists connected with the district, at Barrow-in-Furness. The institute is not old, and an outline of its short history may be interesting to our readers. In the autumn of 1868 Mr. J. Jones communicated with a meeting of the representatives of the North of England Iron Trade, held at Newcastle-on-Tyne, and suggested the advisability of establishing a technical institute for the iron and steel trades. The suggestion was acted upon, and a committee of leading iron-men nominated, representing all the great centres of iron or steel industry in the kingdom. This committee held its first meeting almost at once, at Birmingham; an institute was organized, and at the commencement of 1869, 150 names were registered of gentlemen willing to join the society. His Grace the Duke of Devonshire was requested to become the first president; he consented, and the institute was formally constituted in February, 1869. The Duke's inaugural address was delivered in London in the following June. As the members are scattered all over the kingdom, more than two meetings in the year cannot well be held, and consequently it was arranged that each meeting should extend over some days, and that one meeting should be held in London in the winter, but that the summer one be not fixed to any special place, and thus these meetings have been held as under:—

Middlesborough	1869
Merthyr	1870
Dudley	1871
Glasgow	1872
Liége	1873

Each of these districts gave the members a most cordial reception. Some idea of the progress of the institute may be gathered from the statistics of the number of members, thus:—

the last day of 1869 the number was 292, while on December 31, 1873, the number was 644; and at present it equals about 800. Mr. Henry Bessemer succeeded the Duke of Devonshire as president, and he in turn gave place to Mr. Isaac Lowthian Bell, a gentleman of world-wide reputation on all technical questions concerning the phenomena of iron smelting, and a most courteous and affable gentleman as well.

The institute does not confine itself merely to its own transactions, but embodies with them all the extraneous information that can be gathered on cognate subjects, either at home or abroad, by gentlemen specially appointed to the task. The institute also is simply scientific and technical in its operations, and takes no cognizance of financial disputes between labour and capital.

Having briefly sketched the history of the institute, it may be as well to give a similar *précis* of Barrow-in-Furness. The town itself rivals the towns of the United States in the rapidity of its growth, having multiplied its population six-fold in the ten years between 1861 and 1871. This astonishing progress is principally due to the judicious fostering of the industries for which the district is best suited, whether from its mineral wealth or its geographical position, by the Duke of Devonshire, Sir John Ramsden, and others. The town stands beside an arm of the sea, dividing the island of Walney from the mainland of Furness, on the extreme north-west coast of Lancashire, and it stretches along the shore from south-east to north-west, between Salthouse at the former, to the works of the Barrow Hæmatite Steel Company at the latter extremity; and the streets are wide and straight, the principal ones, called Hindpool Road and the Strand, being 50 ft. wide, while their continuation—Walney Road—is 60 ft. in width, and all three conjoined form a direct line from the railway station to the steel works. Nearly parallel with this runs the chief tradesmen's street, where the best shops are, and it is 60 ft. wide at the narrowest point; at right angles to it runs the Abbey Road, as it is called, presumably because it is the way to Furness Abbey, about two and a half miles distant. Abbey Road begins at Hindpool Road, and where it crosses Duke Street a very fine square, or, in one sense, a very fine "diagonal," is constructed—diagonal, because it stands thus to the streets which enter at the corners, not in the middle of either of the sides, as is usually the case. This Abbey Road will hereafter form a beautiful thoroughfare; it is 80 ft. wide, and in the "diagonal" a fine statue of Sir John Ramsden is placed. Near to this a railway station for the town is to be constructed for passenger and general traffic; the present station will be then devoted to the service of the docks. The corporation have made a municipal regulation, greatly to be commended, viz.: that no new street is to be less than 40 ft. wide, so there will be the less chance of those miserable rookeries which are such plague-spots in other of our large towns.

As regards the local industries of the town, undoubtedly the *pièce de résistance* is the Barrow Steel Works, which employ about 3,000 hands, and have a splendid plant of eight blast furnaces, besides steam-hammers, plate and rail mills, Bessemer converters, and every appliance of the most recent pattern for the manufacture of iron and steel of the finest quality. Besides this establishment, there is a very fine iron shipbuilding yard, two very fine docks—the "Devonshire" and the "Buccleugh,"—a railway rolling-stock works, a foundry, a flax and jute works, themselves worth a long journey to inspect, and some other works of importance. Besides all this, the Sanitary Board of Health is a vigorous and enterprising one, and Parliamentary powers were obtained about two years ago to expend £30,000 on drainage and waterworks. A private company at that time had the then waterworks, but by the advice of the Borough Surveyor, Mr. Jacob, the Corporation purchased the works, and charge a rate for the water, the transaction proving a very profitable one for the Corporation. Space forbids our enlarging on the progress of what is just now one of the most interesting of the centres of the iron industry of Great Britain, and we must hasten on to the meeting itself. The proceedings formally commenced on Tuesday, the 1st September, by the transaction of some routine business by the Council, after which the members rambled about, and paid informal visits to some of the factories and works; many of them, indeed, had to devote their energies to hunting up beds, which were hard to get, nearly every available bed having been engaged for weeks in advance. On Wednesday, at 10.30, there was a general meeting in the Town Hall, Mr. J. T. Smith, the mayor, opening the proceedings; some routine work in the reading lists of retiring members, scrutiny of voting papers, &c., being completed, the reading of the papers contributed by the different members was begun by the reading of Mr. Wurzburger's, of Dalton-in-Furness, on the Geology of the West-coast Iron District. The heads of the paper were: 1, Geological Formation; 2, Geological Situation and form of the Hæmatite Deposits; 3. Mineral Compositions of the Deposits, and concluding remarks. The *résumé* of the paper is this:—The author pointed out in the first division that the rocks of North Lancashire and Cumberland are of an ascending order to the Lower Silurian carboniferous and Permian formations, covered here and there by drift; the mountains of the Lake district are chiefly Lower Silurian, and consist of four divisions: 1, slates; 2, green slates and porphyries; 3, Coniston limestone; 4, Coniston flags and grits. The older rocks, together with the Upper Silurian sandstone, are surrounded by a band of mountain limestone, and it is this which contains the principal deposits of hæmatite in the Furness, Millom, and Whitehaven districts. The carboniferous formation at Whitehaven, as far as known, consists in the lower part of a massive limestone, 250 ft. thick, followed by thin beds of limestone shale and sandstone; the area of the mountain limestone in which iron ore has been proved to any extent is in Furness, about seven miles from west to east, and about a mile in its greatest width. In the second division the author of the paper said that the deposits A in the old Silurian rocks are veins running nearly north and south, tending somewhat westerly, while the dip is sometimes west, sometimes east, and at angles varying from 45° to 80°. The usual width of the veins is 12 ft. to 14 ft. of nearly solid ore. At Kelton and Knockmurton about nine veins are known, of from 3 ft. to 14 ft. wide. The author went on from this to describe the mountain limestone deposits, the occurrence of "pockets," or caverns, and he then gave some interesting particulars of the Barrow formations. The discussion was brief, as, indeed, were those on all the papers, time being so limited.

The next paper was by Mr. A. Brogden, M.P., on the Rampside boring, where a search is being instituted after coal, the present want of which is the only hindrance to the Barrow industry; the gist of the paper was on the importance of the search to Barrow interests, and that the adventurers ought not to let merely theoretical geologists dishearten them by saying there was no chance; as experts were often misled by freaks of Nature, and that no fixed rule could be laid down. The discussion on this paper was the most remarkable of any at the meeting, from an anecdote told of an old farmer who took it into his head to search for coal; scientific men deprecated the idea, and said there was none there; he began, however, to bore, and worked to a great depth without success; he was again advised to desist from the search, but he averred that "he would find the coal, and, failing that, he would bore to h—l and get cinders!" and whose pertinacity was crowned with success, as he found coal, though at a great depth.

The next paper was by Mr. Charles Smith, on the iron ores of Sweden; in that paper he said that Furness alone produced annually more iron ore and iron than the whole of Sweden, but that the extraordinary fine quality of the Swedish ores made the trade not simply one of quantity but a remarkable one in other respects, the Swedish ores, while nearly all of one class, vary considerably in richness and yield, the ores are either magnetic or red hæmatite and contain from 30 per cent. of iron up to nearly chemically pure iron. A small quantity of brown hæmatite is found in the south, in the bogs of Finland, and in winter the same sort of ore is dredged from the bottoms of certain lakes in the same province; as a rule the percentage of iron in this ore is only 25, about, with stray samples of 50. According to official statistics, the average yield of the mountain ores is under 50 per cent. In 1872, 718,000 tons were raised from 671 mines, and 33,000 tons of iron manufactured, but of the former, 12,000 tons were bog and lake ores, with very low percentages, and about the same quantity of the mountain ore was exported to Finland. Next to the iron oxide, the main constituent of Swedish ores is silica, while phosphorus is only present in the percentage of 0·05, and sulphur, with one or two exceptions, is nearly absent also. The surface of Sweden is mainly covered with Plutonic rocks, granite being the most abundant; a considerable area, however, is occupied by gneiss, mica-slate, and varieties of porphyry, and also a felsparic rock, peculiar to Sweden, and called helleflinta, which is of great importance, as being a sure indication of the presence of iron.

The Bisberg mines claim an antiquity of 600 years, they are thirty miles south-east of Falem, and the ore is one of the richest in the kingdom; the ore, from its exceeding richness, is much esteemed for mixing; the operations are, however, small, about 15,000 tons per annum, and the isolation of the place is a great drawback.

Mr. Smith went at considerable length, most exhaustively into his subject, and his paper and the discussion were most valuable and interesting, but we are unable to follow his example for lack of space, much to our regret. This terminated the papers for Wednesday, and at 1 p.m. a general move was made, first for refreshments and then to visit the Barrow Steel Works, which were of great interest and in full operation; amongst other items attracting attention being a

Howard safety boiler, which has given the company, we understand, great satisfaction. From the steel works the company went to the shipbuilding works, and a steamer was launched successfully. The steel rail mill, at the steel-works, formed a great attraction, and the conversion of an ingot of steel, in a few minutes, into a rail, was attentively watched, as were also the tire-mills, the blowing engines, Bessemer converters, &c. The day wound up with a banquet supplied by Gunter, from London, at the expense of the Steel Works Company, while the Duke of Devonshire contributed the venison; and about 460 gentlemen sat down in the drawing-office of the shipbuilding works, which was handsomely decorated. His Grace the Duke presided, and the usual speeches, &c., were duly made and honoured.

On Thursday papers were read and discussed in the Town Hall till 1 p.m., when a special train, subsequently divided, conveyed members to Millom and Ascham Iron Works respectively; splendid luncheons being provided by the owners of the districts visited, and duly honoured. The best paper read perhaps before the Institute, was one by a gentleman, Mr. A. L. Holley, of New York, of world-wide fame in connection with ordnance, on Rolling Mill Machinery in the United States.

On Friday everyone had to arise betimes to catch the 9.30 special to Whitehaven and Maryport; and splendid iron works were visited at the Cleator Iron Smelting Works at Workington, which claim to be the oldest smelting iron works in the district. The train proceeded from Barrow, through Dalton, and by way of Sellafield to Cleator Moor; at this latter place the Montreal Iron Ore Mines were visited, and here was to be seen a drift of an iron mine laid open by a slip of earth. The drift was about 60 ft. deep, and a vein of ore at least 40 ft. thick was laid bare, as far as could be seen; the quality of the ore is uniform and giving a good percentage.

From the Cleator Smelting Works the train proceeded to Workington, where part of the company remained to view the works in the neighbourhood, while the remainder went to Maryport, where the Maryport Iron Works, and the Solway Hæmatite Iron Works were visited. At the latter place are two fine blowing-engines, of respectively 120 nominal horse-power, double cylinders, 5 ft. stroke; fly-wheels 30 ft. diameter. Returning to Workington, the West Cumberland Hæmatite Iron Works were visited. Here 2,500 hands are employed; there are five blast furnaces, 65 ft. high and 25 ft. diameter in the boshes, capable of producing an aggregate of 1,600 tons of pig-iron per week. The steel works contain four Bessemer converters, able to produce 600 to 700 tons of steel per week. The works are half a mile long, and though rails are the *spécialité* of the place, plates are also made. The rail mill is said to be able to produce about 1,100 tons of rails per week. The Solway Firth, on the west of the works, forms the place of shipment, as well as a bed for the slag, which is thrown into the sea here.

From Workington, the company proceeded to Whitehaven, the train slacking speed to let the passengers have a good look at various iron works on the route—such as Moss Bay, Harrington, Paston, and Lord Lonsdale's Works. The company proceeded to Whitehaven Castle, where luncheon was served in the riding-school.

IMPORTANT BOILER EXPERIMENTS.

A SERIES of experiments is being conducted by the Manchester Steam Users' Association at Mr. Beeley's works, Hyde Junction, with a view of determining by experiments the effect that cutting openings in the shells of cylindrical boilers has upon their strength. Sometimes these openings are introduced at the base of steam domes, and sometimes for carrying downtake flues through the outer shell. In the French or "elephant" boiler, these openings are inherent at the connecting necks, between the lower and upper cylinders. In order, therefore, to test the effect of these openings, even to the bursting point, a full-sized boiler of the Lancashire type, having a diameter of 7 ft. in the shell, and 2 ft. 9 in. in the furnace tubes, has been constructed and subjected to a series of tests. The first of these tests was made on Wednesday, the 9th inst., when the boiler had riveted to it a small wrought-iron steam dome, of the same size and strength as many of the connecting necks now in use in the French, or "elephant," and other types of boiler. In preparation for this test, the boiler was very carefully gauged in every direction, and six observers took measurements at various points of its movements, under the gradually-increasing pressure. It was found that the furnace tubes, which were strengthened with flanged joints at each of the ring seams of rivets, were quite immovable, which is satisfactory, inasmuch as their sufficiency for high pressure was impugned at the recent explosion at Blackburn. The ends of the boiler breathed outwards very slightly, and resumed their original position as nearly as may be on the pressure being relieved. The longitudinal seams in the outer shell exhibited no movement. The steam dome or neck, however, burst when the pressure reached 250 pounds on the square inch, showing that it formed the weakest part of the boiler. On the following day, the boiler was again submitted to hydraulic pressure, the wrought-iron steam dome having been removed, the opening blanked up, and a cast-iron man-hole of very substantial pattern applied. At a pressure of 200 pounds on the square inch, the cast-iron mouth piece ripped asunder, the rent extending right across the plate at each side, and into those adjoining. A wrought-iron raised man-hole mouth-piece, with which the boiler was fitted, resisted both tests without the slightest signs of distress, though repeatedly gauged. These tests show how weak those boilers must be in which the man-holes are altogether unguarded, while for high pressure mouth-pieces made of cast-iron must give place to wrought; and also that the openings at the base of steam domes have a decidedly weakening effect, so that they should always be dispensed with wherever it is possible to do so. It is proposed to push the experiments still further under other conditions, so as to detect any weak points that may still lurk in the systems of construction now adopted for high-pressure boilers of the Lancashire type. In addition to the above, a trial was made of the discharging power of a low water safety-valve. The importance of an investigation on this subject was suggested by the recent explosion at Hull which was attributed to shortness of water, though the boiler was fitted with a low water safety valve. The experiments seem to show that the discharging power of these valves is not as high as it is desirable it should be, that they will not reduce the pressure of the steam as rapidly as has been supposed, so that their construction requires further consideration at the hands of the makers. It is intended to extend the experiments on this subject to other low water safety-valves of different constructions

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE American Association for the Advancement of Science has held its annual meeting at Hartford during the past and present week. The most important business before the meeting has been the consideration and adoption of a new constitution, designed to remedy a long-continued evil growing out of the popular character of the association. The scientific character of the papers and proceedings has very frequently been such as seriously to compromise the standing of the association in the scientific world. To remedy this it has been decided to select from the members those who are engaged in science and form them into a separate class of "Fellows." All the officers of the association are now to be chosen from this class, and the power of the several committees to exclude improper or unsuitable communications has been increased. All friends of science will await with interest the working of this improvement. The necessity of some vigorous and effective measures must be obvious to anyone who will simply examine the lists of papers presented for reading. Among some hundred authors, the number of really eminent men may be counted on one's fingers, while the large majority are entirely unknown, and present papers which, so far as can be judged from their titles, are of no scientific importance. We greatly doubt whether this evil will be cured by anything short of a radical change in the publishing system of the association. So long as there is a volume of "Proceedings" to be published, so long will there be a pressure on the part of the less desirable class of members to have their papers printed, and this pressure can be resisted only by a little more moral courage on the part of the Standing Committee than it has hitherto exhibited. While such papers are admitted, we may be sure that few of the abler members will wish their productions to be seen in such company. It is gratifying to notice that the present meeting exhibits a decided improvement in this respect, and that notwithstanding the general unimportance of the communications, the subjects of ether and atoms do not appear among those discussed before the association.—*New York Nation, Aug.* 20.

THE PRACTICAL NOTE-BOOK OF TECHNICAL INFORMATION USEFUL TO STUDENTS AND WORKMEN.

(78.)

THE Describing of the Eccentric Curves, Ellipse, Cycloid, &c. &c.—Having given various methods of finding the curves of ellipses by means of arcs of circles, and by finding a number of points, we now describe a *method of finding the curve of an ellipse on a large scale*, such as the elliptical curves used by gardeners in setting out their plots, &c., &c. This method is illustrated in fig. 402, in which *a b* is the minor, *c d* the major axis of the ellipse to be described. These being drawn on the ground or other surface on which the ellipse is required to be described, at right angles to each other, with the distance *c e*, half of the major axis, as radius from the point *a* as a centre, describe the arc *f g*, cutting the axis *c d* in the points *f* and *g*. In the points *f* and *g* fix firmly two pins, to one of which, as *g*, tie firmly the end of a piece of cord. Make the length of this cord equal to twice the distance *c g'*, and tie firmly the other extremity of it to the pin *f*. Tighten the cord by inserting a pin, tracing point, or pencil at *h*, and by keeping moving the pencil from right to left, or *vice versa*, one curve of the ellipse will be described by the point of

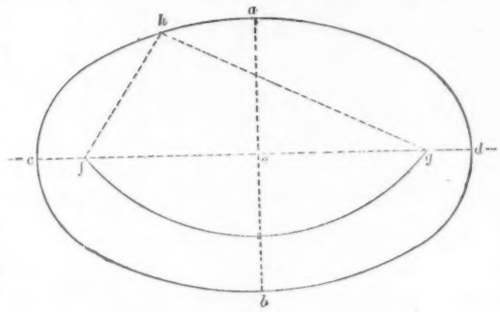


Fig. 402.

the tracer. It is scarcely necessary to say that the cord must be kept tightly stretched during the operation. As it is not easy to tie the cord at the second pin *f*, and so that it shall be twice the distance of *c g'*, an easier method is to put in another pin at the point *a*, and, first securing the cord to the pin *g'*, bringing it round the pin *a* and securing it to pin *f*, finally taking out the pin *a* and inserting the tracing-point as at *h*, keeping the cord tight. The tracing-point may be moved first from *a* to *d*, and from *a* to *c*, which will give the upper half of the ellipse; the lower half will be obtained by repeating the process, removing the cord to the under side of the major axis *c d*. The curve described by this method gives a very accurate outline of an ellipse. A very good outline can also be obtained by the use of the instrument known as the "trammel," roughly illustrated in fig. 403. It is composed principally of a brass cross, *a b c d*, armed on the under side with sharp pins, so that by pinning the cross down on the paper, it will be secured to its surface. The arms of the cross are provided with slots at right angles as at *e*, in which slots the lower parts of the pins *f* and *g'* are capable of sliding. These pins are connected with the long arm *h h*, which carries at its extremity a pencil, or tracing-point *i*. In using this instrument the two slots *a c*, *b d*, are placed to be coincident with the two diameters of the ellipse, their point of intersection coinciding with the point of intersection of the two diameters of the ellipse. The pins are adjusted and fixed by screws to the

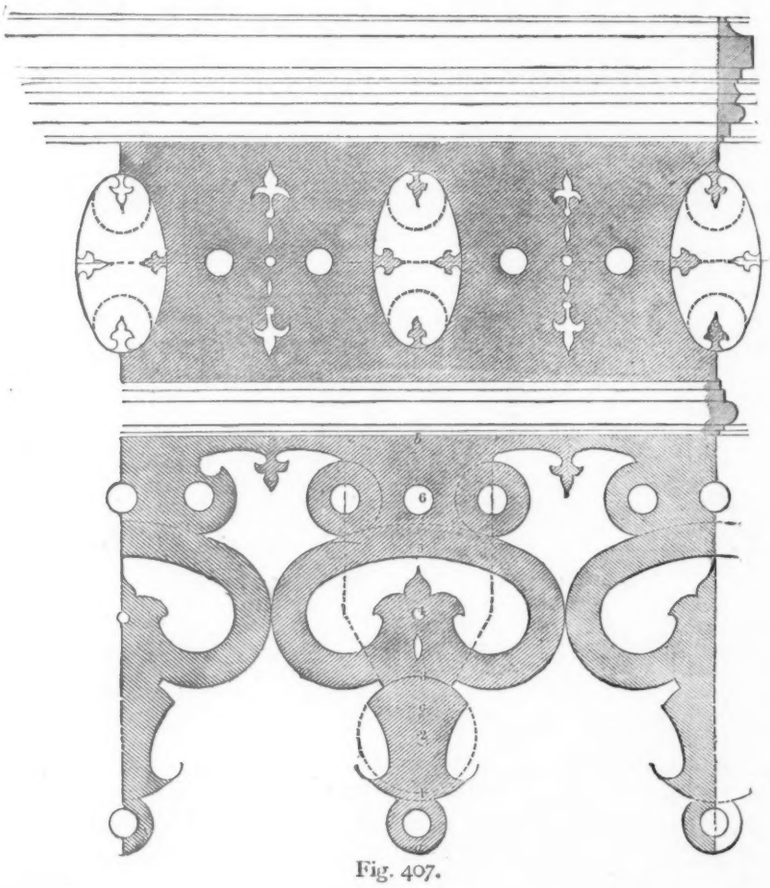


Fig. 407.

Fig. 404.

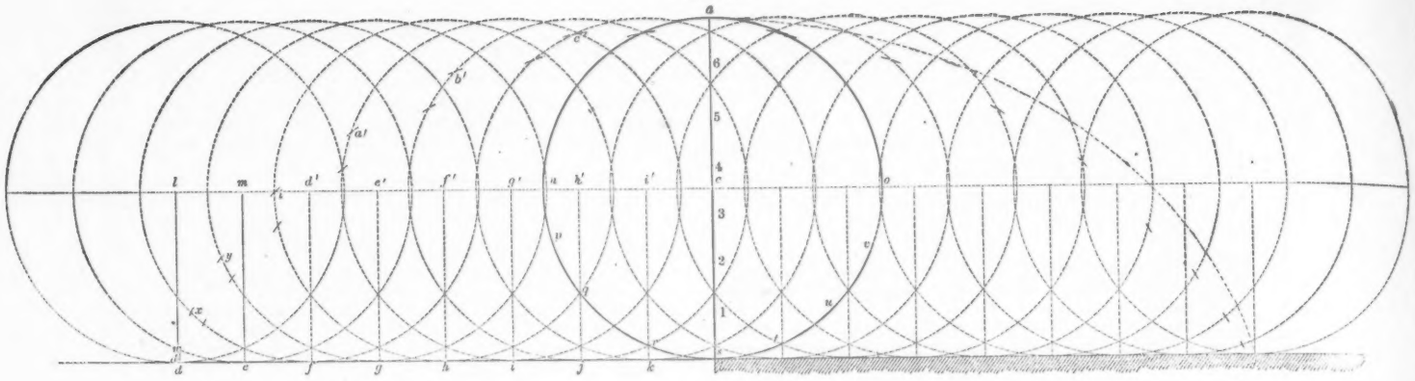


Fig. 405.

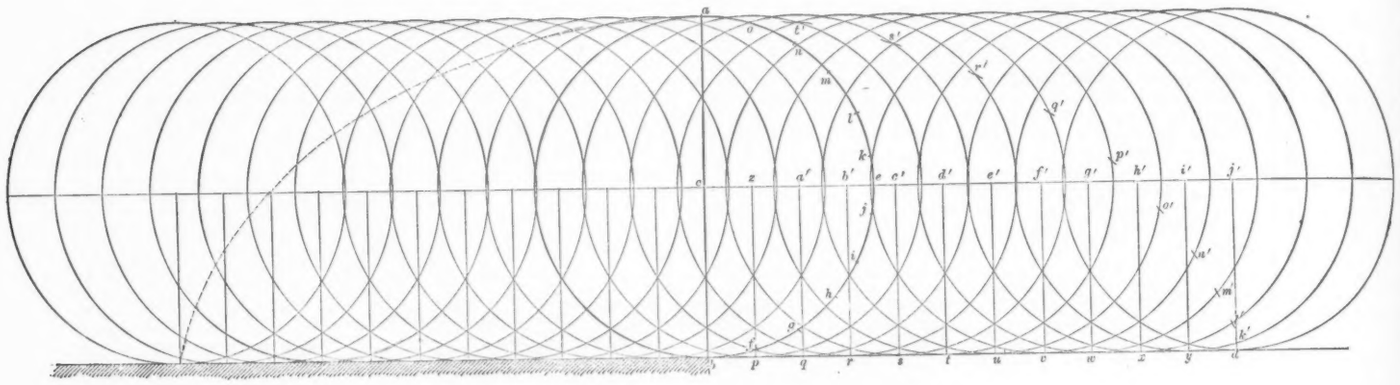


Fig. 409.

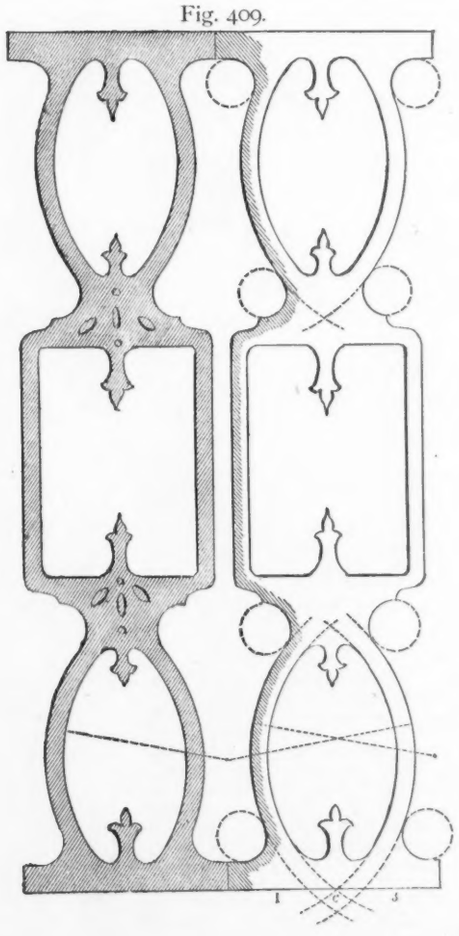


Fig. 406.

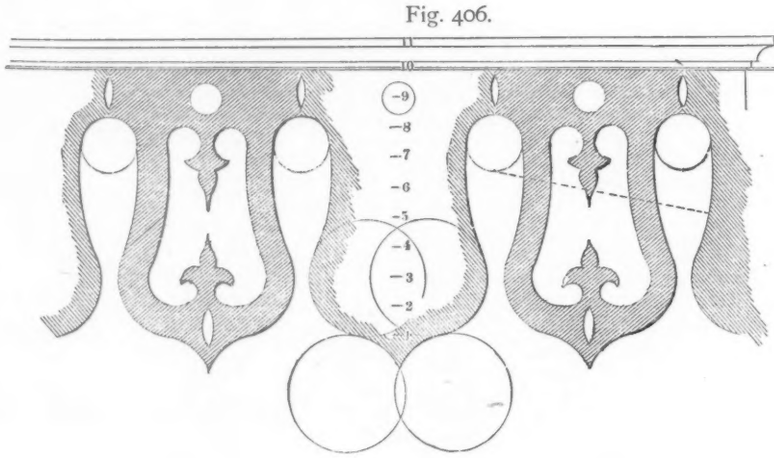


Fig. 411.

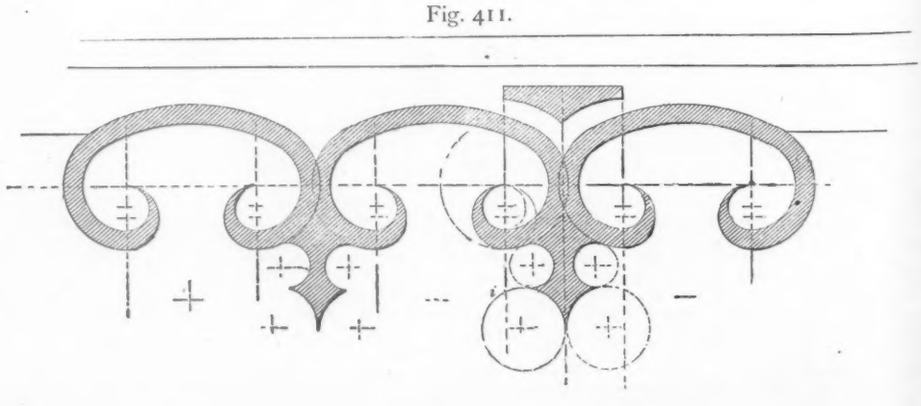


Fig. 419.

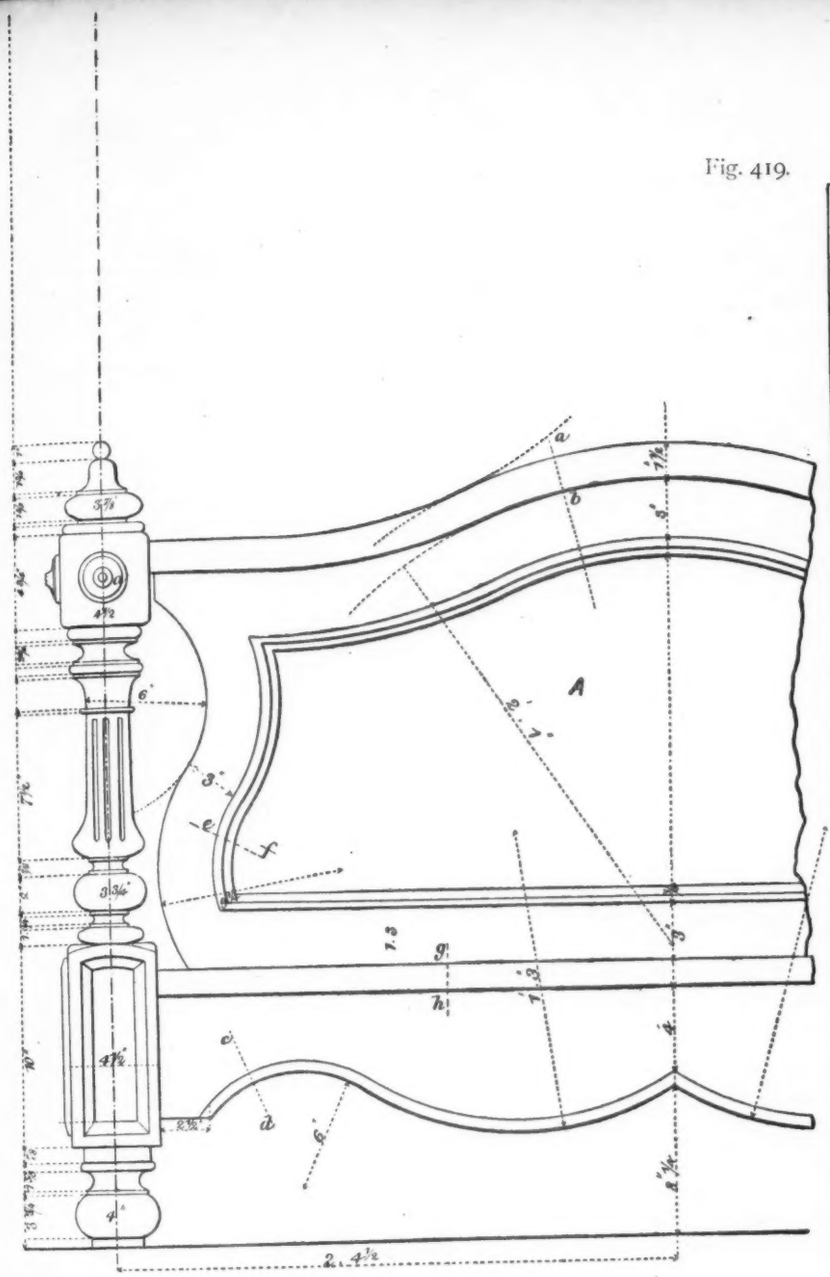


Fig. 413.

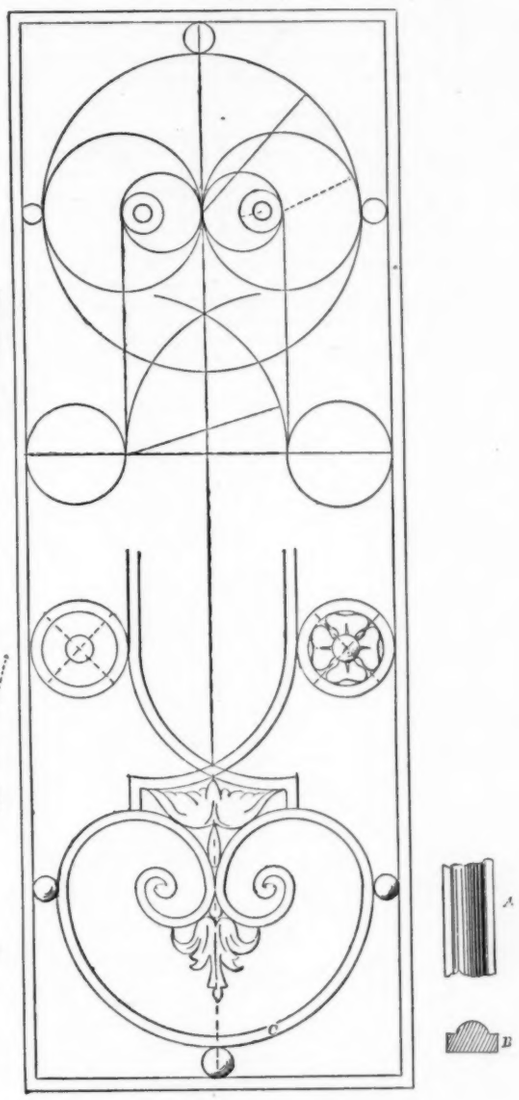


Fig. 415.

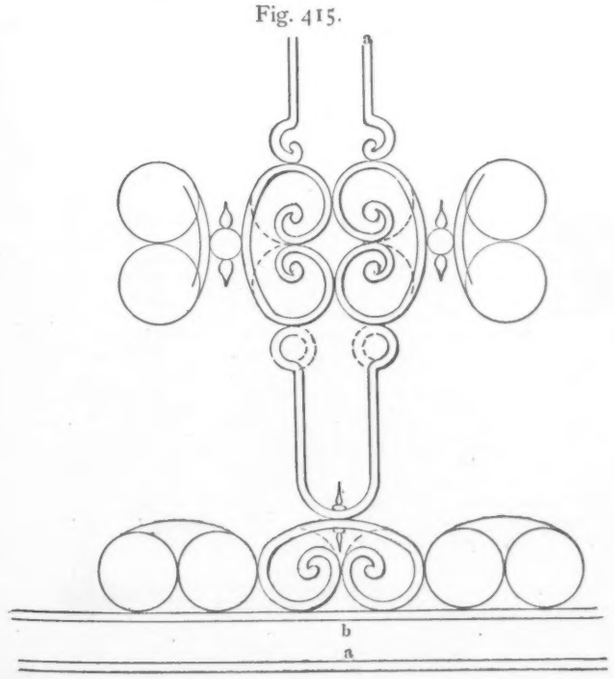
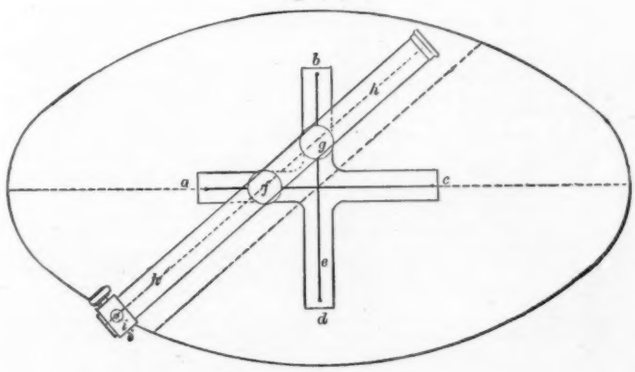


Fig. 415 *a*.

Part between a b

Fig. 403.



bar *h h* into any point required, so that the distance of the centre of the pin *g* to the tracing-pin *i* be equal to half the length of the major axis of the ellipse; and the pin *f* distant from *i* equal to half the minor axis of the ellipse. This adjustment of the pins being made, the sliding point of the pin *g* is placed in the slot of the arm *b*, and the pin *f* on the slot of the arm *a*. By moving the pin *i* round gently, the curve of the ellipse will be described, the pins moving in the slots, *a*, *c*, *b*, *d*.

To describe the Curve known as the Cycloid.—When a circular body, as *a b c*, fig. 404, rolls along and completes a revolution upon a plane surface, as *b d*, the length of which distance *b d* is equal to the circumference of the circle, any point in that circumference will describe a curve known as the "cycloid." The relation of the length of the plane to the circumference of the circle gives a method of describing the curve as follows:—Let *a b*, fig. 404, be the diameter of the rolling circle. From the point *b* draw at right angles to *a b* a line *b d*, and make *b d* equal to the

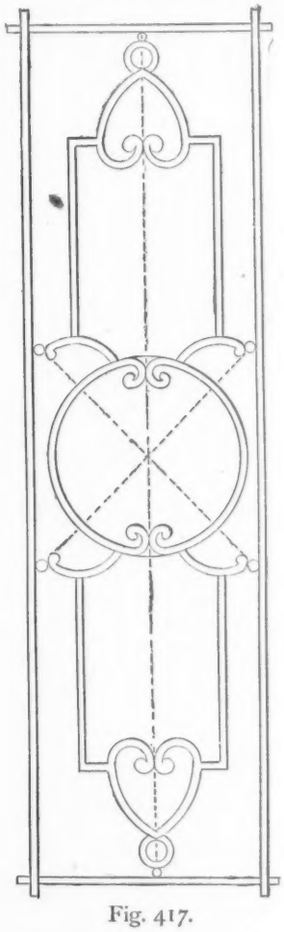


Fig. 417.

circumference of the circle *a b c*. If the line *b d* is made equal to eleven of the seven parts into which the diameter *a b* is divided, this will approximate nearly to the circumference of *a b c*. Next divide the distance *b d* into any number of equal parts, say eight, as in the drawing. From these points, as *e f g h*, &c., draw at right angles to *b d* lines as *d l*, *e m*, cutting a line *c m l* drawn parallel to *b d* through the centre *c* of the circle *c b a*. Next divide the semi-circumference *n b o* of the rolling circle *a b c* into the same number of equal parts as the distance *b d* is divided into, as in the points *p q r s t u* and *v*. Next, from the points on the line *c l*, as *l m*, &c., describe circles of the several diameters, equal to *a b c*. Next take in the compasses the distance *n p*, and from the point *e* on the line *b d*; cut with this distance the circle, the centre of which is at *m* on the line *c l*; the point of cutting is at *w*. Then, with the distance *n q* from the point *f*, cut the circle described from the centre *d* on the point *x*. Next take the distance *n l'*, and with it from the point *g* (on the line *b d*), cut in the point *y* the circle described from the centre *e'* (on the line *c l*). Next, with the distance *n s*, from the point *h* (on the line *b d*), cut in the point *z* the circle described from the centre *f'* (on the line *c l*). Next, with the distance *n t* cut in the point *a'* the circle described from the centre *g'* (on the line *c l*). Next, with the distance *n u* cut in the point *b'* the circle described from the centre *h'* (on the line *c l*). Finally, with the distance *n v*, cut in the point *c'* the circle described from the centre *i'*, on the line *c l*, a series of points as *d w x y z a' b' c'*, will thus be obtained, through which by hand or a "set curve" the cycloidal curve may be drawn. This will give half of the curve due to a semi-revolution of the rolling circle *a b c*. The whole curve will be terminated at *j*, and the various points of the curve *j a* will be found by a repetition of the operations named above, on the right hand side of the line *a b*.

Another method of finding a series of points through which a cycloidal curve may be drawn by hand is illustrated in fig. 405, in which *a b c* is the rolling circle, and *b d* the line on which the circle rolls. At right angles to *b d* draw the diameter *b c a*. Divide the semi-circumference *a e b* into any number of equal parts, as eleven, as in the drawing in the points *f g h i j k l m n* and *o*. Then from *b*, on the line *b d*, set off the same number of equal parts as at the points *p q r s t u v w x* and *y*. Next, from these draw at right angles to *b d* lines as *p z*, *q a'*, *r b'*, *s c'*, &c., cutting the line *c j* drawn through *c* parallel to *b d*. Then from the points *z a' b' c' d' e'* &c., &c., as centres with radius *c a*, describe circles equal to *a b c*. Next, with the distance *b f* from the point *y* cut in the point *k'* the circle described from the centre *i'* (on the line *c j'*). Next, with the distance *b g* from the point *x* cut in the point *l'* the circle described from the centre *h'* (on the line *c j*). Next, with the distance *b h* cut in the point *m'* the circle described from the centre *i g'* (on the line *c j'*). By taking in successive lines the distances *b i*, *b j*, *b k*, *b l*, *b m*, *b n*, and *b o*, and cutting from the points *v u*, *t s*, *r q* and *p*, the circles described from the centres *f' e' d'*, *c' b' a'* and *z'*, a series of other points, as *n' o' p' q' r' s'* and *t'* will be obtained, through which a curve may be drawn by hand, giving half of the cycloidal curve *d q' a*, the other half being put in by a repetition of the same operation as described above.

(79.) **Cut Wood.**—Resuming our sketches in this department we give in fig. 406 a design for a single eaves-board, and in fig. 407 a design for a double one; and in fig. 408 a design for a bracket. In fig. 409 we give a sketch adapted for a balustrade or balcony rail. In fig. 410 we give a design for a perforated or for an inlaid part, with the working lines and centres shown; in fig. 411 a design for a barge board, and in fig. 412 a design for a centre piece.

(80.) **The Elements of Iron Construction**—*Section Second, Ornamental Work.*—In next number we shall continue our remarks on beams, &c., but in the present number we shall confine the designs we have to give to those connected with work for railing, as in fig. 413, in which A gives part of C in elevation, B being the section. Other designs are given in figs. 414, 415, 416, 417, fig. 418 being a design for a centre-piece.

(81.) **The Elements of Cabinet-Making Design.**—Continuing our sketches in this department we give in fig. 419 a design for foot-board of a Tudor bedstead with sizes marked.

DOCK EXPANSION IN THE WEST.

III.

IN the last session of Parliament, the Alexandra Dock Company of Newport have had their final legislative troubles, and in the month of October this new and splendid dock is to be formally opened. There is something very remarkable in the rise and progress of the town and port of Newport. It has not been so striking as in the case of Cardiff; but Newport has had no Castle influence to promote its prosperity, it has not had the abundant resources, and the unity and simplicity of action that have belonged to the Bute trustees. The townfolk, however, have showed no want of energy and ability in their schemes of dock expansion. At the commencement of the last century there was absolutely no shipping at all on the bosom of that noble river, the tidal Usk; occasionally, a solitary trading smack, or the fisherman in his coracle, sought the salmon which is still the profitable boast of the Usk stream. The beginning of the port arose when the Tredegar family, at the beginning of the last century, started a trading smack to

Fig. 418.

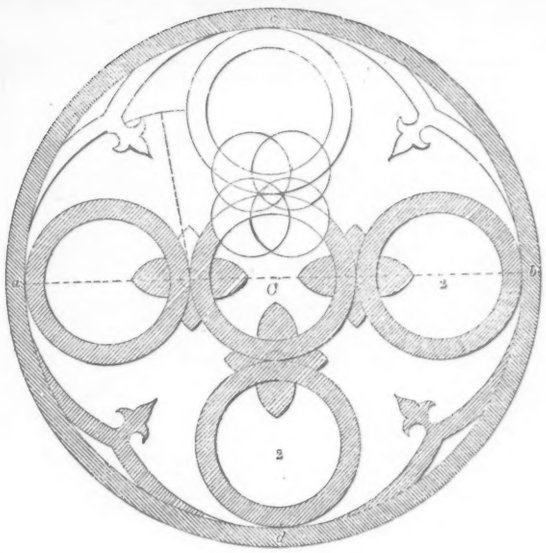


Fig. 412.

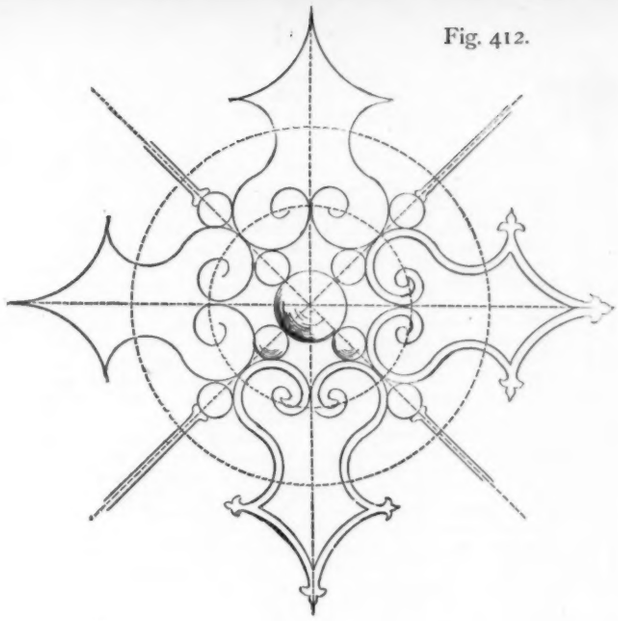


Fig. 408.

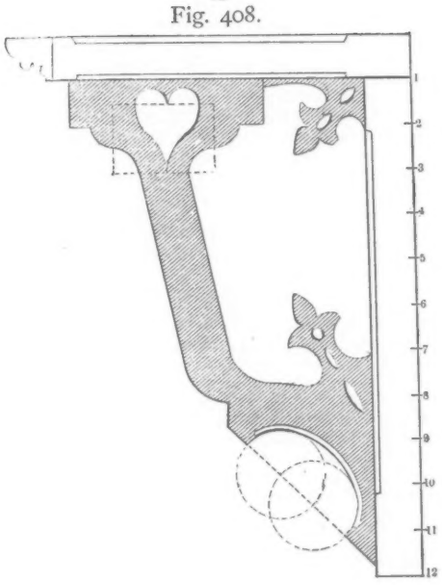


Fig. 410.

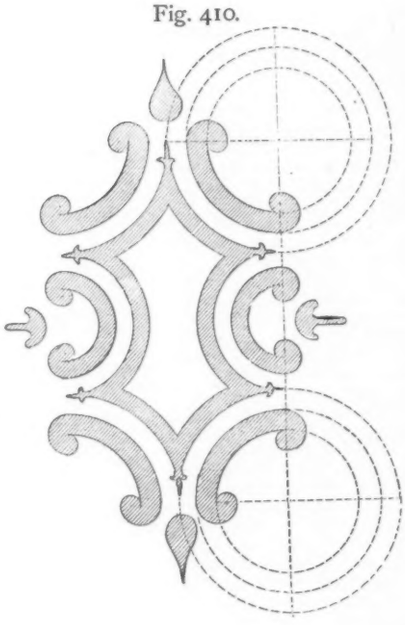


Fig. 414.

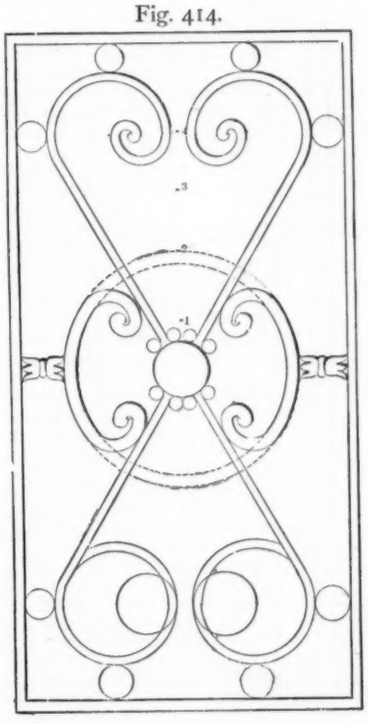
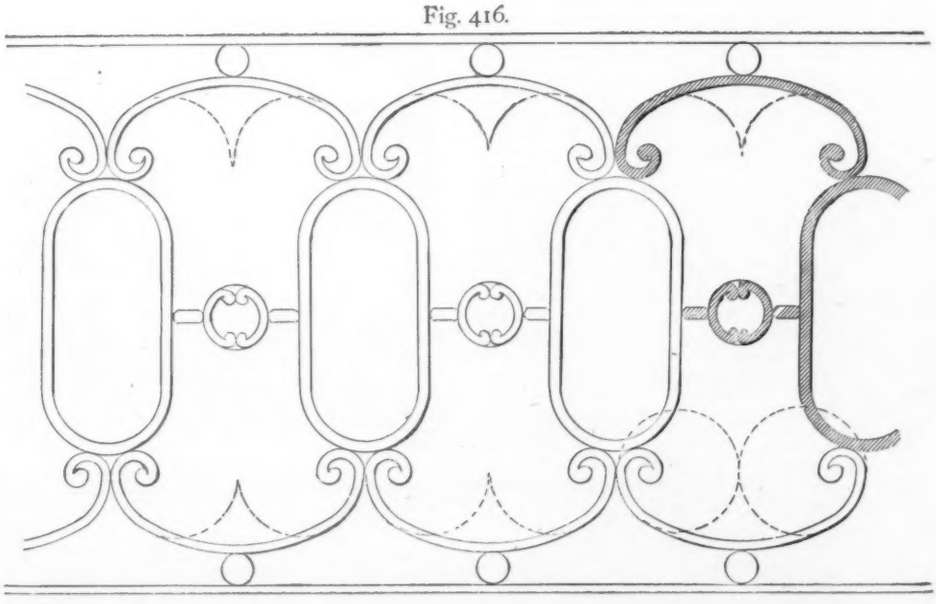


Fig. 416.



Bristol, of some forty tons, called the Tredegar boat. The Newport people saw their sons embark on a voyage to Bristol with the same feelings with which they would now see them off to the Antipodes. Nor was the feeling altogether unreasonable. So little was the intricate, perilous navigation understood, that the boat was lost and all hands drowned. Monmouthshire slept in a very primitive condition until the advent of the Victorian epoch. A curious dialogue once took place between a member of a House of Commons Committee, and Valentine Morris, who created the glories of the Piercefield domain on the Wye river. "What sort of roads have you in Monmouthshire?" asked the member. "No roads at all," was the reply. "How do the inhabitants travel from town to town, then?" "Through ditches," was the reply. The explanation of this odd answer is, that in unsettled countries people generally travel in the summer, the dry water-courses of rivers affording practicable roads. The river is a natural engineer, and opens up roads for itself. In such primitive times, a solitary constable guarded the peace of Newport. The English people who came over to Newport—in those days Monmouthshire was a Welsh, whereas it is now constituted an English county—were exceedingly unpopular, considered foreigners, and, in the striking vernacular of the country, were called "ein Sais Jaul." The Newport people learned, however, to prize the quality of the energy, skill, and capital imported in the English element.

The Monmouthshire Canal was the first step in the progress of Newport, just as the Glamorgan Canal was the first step in the progress of Cardiff. The country gentlemen—among whom should be specially mentioned the great county family of Morgan, ennobled under the title of Tredegar—became anxious to develop the minerals on their estates. Land could then be bought for five shillings an acre, which, within a few years afterwards, was sold at £1,500 an acre. Before the act passed in 1792, the traffic was conducted on the backs of mules. In due course an act was obtained for the improvement of the town. Later on, the few oil lamps that hardly broke the darkness of the streets, were exchanged for gas. Newport was now obtaining for itself a certain amount of shipping. It no longer considered itself as being merely "a creek of Cardiff." It rejoiced in being classified as "a sixth-rate port." In 1701, that mother port, with its three creeks of Newport, Penmarck, and Aberthau, only possessed eleven vessels among them, amounting to 218 tons. A great step was made in 1835, when the royal assent was given to the first Newport Dock Bill. The amount of labour and engineering required in the construction of the dock was very great; the expenditure was about £200,000; the extent of ground occupied by docks, wharfs, and warehouses was twenty-four acres; the actual area of the docks was four and a-half acres. It appeared from the excavations that the ground or banks of the Usk, for a considerable distance, was formed to a great depth by the lodgment of sediment from the water which, before the erection of sea-walls, frequently overflowed the country. It is curious to refer to the language of a guidebook, which, though published so late as 1847, has quite an archaic sound when we refer to the progress of the town:—"The river Uske, which rises in Brecknockshire, amidst the Black mountains, continues its devious course through many a pleasant scene, till it embraces Newport, and rolls down to the Severn. Near the river's mouth a lighthouse is erected, its site being considered by navigators, however, anything but proper. True, commerce at present has the necessary conveniences; but, regarding the progress in the past few years, and anticipating a corresponding progress in the future, we may reasonably infer that the advantages of the river will shortly be fully exercised. The establishment of a first-rate ferry conveyance across the river, from the neighbourhood of the new market, must soon take place; while the formation of a patent slip and ship-building yard on the east bank of the river, near Liswerry Pill, will tend to raise a large increase to the town, ultimately, on this side of the water." All these prophecies and prognostications have been more than verified. Yet Newport has had its misfortunes and drawbacks. A large wooden railway-bridge was built over the Usk and burned down. A large bank was founded and failed. The famous Chartist riots did the place no good. In course of time the trade of the town outstripped the accommodation. In 1858 a still larger dock, seven and three-quarter acres, was constructed. After very prolonged labours, the Alexandra Dock has been just formed, to be outstripped in its turn, in the course of the growing development of the future.

The following comparison between the Newport Old Dock accommodation and that which will be furnished by the Alexandra Dock is full of interest:—

The existing dock at Newport has an area of 11¼ acres.
The lock is 225 ft. long.
" 61 ft. wide.
Depth of water—high spring-tides . . 30 ft.
" " neap-tides . . . . 20 ft.
" " lowest tide of port . . 18 ft. 9 in.
Hydraulic coal-hoists.
Ballast-cranes.
The first portion of this dock (4 acres) was opened Oct. 1842.
Second " " (7¾ acres) " Mar. 1858.

A large portion of the trade of the port is carried on at the river wharfs, which extend from Newport Bridge to the Cork Steamship Co.'s wharf, a distance of 2¼ miles.

The following is the statement respecting the Alexandra Docks:—

Length of lock	350 ft.
Width "	65 ft.
Width across trumpet-mouth entrance	350 ft.
Width of River Usk opposite entrance	800 ft.
Depth of water over cut, high-water spring-tides	35 ft.
" " " neap-tides.	25 ft.
" " lowest tide of port	23 ft. 6 in.
" " in dock	30 ft.
Total length of dock	2,500 ft.
Width of dock	500 ft.
Area of dock	28¼ acres.
Area of land for dock, wharfs, sidings, buildings, &c., exclusive of branch railways	200 acres.

The lock provided with four pairs of gates—an outer pair, a tide pair, an intermediate pair, and an inner pair, all worked by hydraulic power, as well as capstans, &c.

On the eastern wall of dock five hydraulic cranes are provided for general purposes. The iron trade will also be carried on on this side.

On the south wall two hydraulic ballast cranes are fixed, and in this wall the round heads for a future extension of docks southwards are built, the Company having power to take an additional 200 acres of land south of the present dock for that purpose.

On the western side of dock seven hydraulic coal hoists are provided on the most approved principle.

The trains of coal approach the staiths on long sidings curving out of the main lines, which are parallel to the dock and 500 feet off. This arrangement will give very great facility for shipping coal.

The dock is connected with the railway system by two short branch lines, one of which forms a junction with the Great Western Railway, and the other with the Monmouthshire Railway, thus securing access to all parts of the country.

The upper portion of the dock is intended specially for the timber trade, for which large accommodation is greatly needed.

The dock is to be opened in October next.

The graving dock, which communicates with the floating dock, is partly constructed—it will be 450 ft. long; width of entrance, 50 ft.; depth of water, 18 ft.

The following table exhibits the Custom House Returns, which show the respective progress of Cardiff and Newport in their shipments of coal and iron, both foreign and coastwise—

	PORT OF CARDIFF.			PORT OF NEWPORT.		
Years.	Coal. Foreign.	Coal. Coastwise.	Iron. Foreign.	Coal. Foreign.	Coal. Coastwise.	Iron. Foreign.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1850	213,697	494,885			402,078	
1851	243,191	496,968			226,439	
1852	352,246	448,781			451,770	
1853	431,779	471,944		104,528	450,413	
1854	576,205	464,552		134,115	506,199	131,313
1855	793,827	455,047		188,714	474,342	109,143
1856	836,647	537,319	131,824	185,255	493,168	142,600
1857	912,044	530,894	124,759	188,123	521,051	106,603
1858	789,921	581,858	126,029	202,072	574,116	102,308
1859	956,576	660,277	174,583	175,453	511,912	92,720
1860	1,142,366	767,846	169,547	188,252	627,669	93,758
1861	1,127,232	887,753	133,014	213,585	615,920	97,734
1862	1,324,513	881,604	172,037	204,730	585,337	94,643
1863	1,490,183	862,765	158,062	186,449	547,334	109,860

In the ten years from 1853 to 1863 the foreign shipments at Cardiff have increased by upwards of 1,000,000 tons, but the increase at Newport over the same period has only been about 80,000 tons. In the same period the shipments of coal coastwise at Cardiff have increased by nearly 400,000 tons, but the shipments coastwise at Newport have only increased by about

100,000 tons. We have not been able to obtain the decennial tables of the last decade. We expect that the figures on both sides will be immensely increased, but the proportion will be hardly affected.

We now revert once more to the neighbourhood of Swansea. Not only has an act been obtained last session for dock expansion at Swansea, but in the same session a similar act has been obtained for the expansion of docks at Briton Ferry, the port of Neath. There were great public rejoicings at Neath when the act was obtained. Briton Ferry is the natural outlet for all the minerals of the Vale of Neath, and indeed for a large proportion of the business that has made its way to Swansea. It is interesting to note, in a report of a special committee of the Harbour Trustees, the story of the perils and expenses of any attempted legislation to promote the prosperity of a port. There were no less than seven sets of petitions against the bill. "One of your committee devoted his whole time, day after day, in going to and fro from the solicitors and chief agents of the landowners and the railway companies who had petitioned against the bill, and made great progress in making arrangements with them, with a view of settling clauses, so as to obviate the necessity of any fierce opposition to the passing of the bill. This became of very material importance in the minds of your committee, considering the resolutions which had been passed, that in case of any severe opposition to the bill it was to be withdrawn." We are glad to say that all opposition was ineffectual or withdrawn; and now, to use the somewhat aspiring language of the proprietors of the little port, they have "the opportunity of placing the port of Neath on a level with those of Cardiff, Swansea, and others in the Bristol Channel."

Marts of activity close by are established on that picturesque, busy spot, Port Talbot, which derives its name from the lord of Margam Abbey, Mr. Talbot, M.P., the Lord-Lieutenant of the county. All travellers by the South Wales line notice the beautiful background to Margam, the oak-clad hill rising 800 ft. All the magnificent domain teems below the surface with treasures of coal and iron. Port Talbot is intended to meet the import and exports of coal, copper, and iron ore to the neighbouring works. Near at hand, at Cymavon, are the immense works of the Governor and Company of the Bank of England.

We may make some brief excerpts from the Report of the Committee of the Commissioners for the Improvement of Neath Harbour, presented this year. The cost of laying down 4,339 tons of slag, together with that incurred in cleaning the river, has entailed an outlay of £928 12*s.* 8*d.* From the commencement of the work, the total quantity of slags deposited has been 937,876 tons. The amount accrued due for the tolls on shipping and goods for the year ending 25th March, 1874, is £3,354 8*s.* 4*d.*

In the early part of the financial year a question arose as to the desirability of increasing the rates upon certain goods, and also the tonnage dues upon ships, up to the limits provided by the act, when, after considerable attention had been paid to the subject, it was decided that the increased rates and dues should commence from the 30th June, 1873, upon various articles.

During the year a third steam tug, called "The Blanche," arrived in the port from North Shields. On the 23rd of May an accident happened to the pilot boat "Black Swan," of this port, resulting in the sinking of the boat, and the loss of one life, viz., William Phillips, the pilot. The boat was subsequently recovered, and is again at work in the port.

The Dynevor Coal Company have erected a full neap-tide quay wall along a part of their river frontage, which is very beneficial in facilitating the cleaning of the layers, as well as materially assisting in keeping them clean.

It will be seen, from the accounts of the treasurer and the collector, that the revenue of the harbour is an increase on that of last year; but this arises from the increased rates and dues having been adopted as before mentioned; at the same time the committee consider that, notwithstanding the numerous strikes of workmen which occurred during the past year—thereby materially deranging the trade of the district—that the state of the revenue of the harbour is very satisfactory.

Such are a few modest details of the present fortunes of this little port, which is now beginning to challenge for itself a noticeable place in the business of the Bristol Channel. We must finally say something respecting the great enterprise of the Channel Dock Company, in the neighbourhood of Bristol, largely made up of the merchants and adventurers of that famous port. The languor and indifference of the past have been exchanged for bustle and activity. In the month of July (and we believe the rate is not diminished), 1,400 men were engaged at the dock works at Avonmouth, the hands being employed in day and night shifts, in addition to between 200 and 300 men employed in quarries on the Wye, near Tintern, very many in the Forest of Dean, in procuring ashlar and rubble, and many in Cornwall in procuring granite for the hollow quoins, sills, and cutwater. The tunnel in the Clifton Extension Railway has yielded a great deal of stone. About 3,000 tons a week are used at the works, and there are five jetties with steam cranes for discharging cargoes of stone. There are five steam mortar mills. The mortar is made of pebbles brought from Aberthau on the Cowbridge river. The hydraulic lime of Aberthau, obtained from the lias pebbles on the beach, is very celebrated. The blue lias limestone is brought to Avonmouth and there burned. They have a reserved store of about 3,000 tons. The lock gates are of timber; five leaves of the three pair are finished. We give, from a carefully-prepared account, some further information respecting these works:—

"The locks are constructed with a view to their being worked by hydraulic power. The sluice ways are tunnels built in the solid wall of the lock, and their dimensions 7 ft. by 4 ft. 6 in. The entrance to each of the sluice ways is formed by seven granite cutwaters, with lintels of massive stones from the Forest of Dean. In all there are six sluice ways, each about 80 ft. in length, and inside are chambers for working iron shuttles and wooden paddles, the purpose of which is to fill the locks at various levels for the purpose of docking vessels. There are three gantries mounted with travelling cranes in the lock, each about 100 ft. in length, and they are used for building sills and hollow quoins. In front of the lock the river is dammed out from the works by means of a substantial embankment, which will be required to be taken away, and shortly the removal of this formidable impediment is to commence. It will be necessary to secure the lock while the operation goes forward, and for this purpose a temporary wooden dam is being constructed at the entrance to the lock. The extreme height of the temporary dam is 70 ft., and the width 75 ft. The works have been in progress for some time, and it may be interesting to our readers to state the actual progress now made. Three granite sills are completed, and the inner sluice ways, with their respective chambers, &c., are nearly finished. The walls of the inner lock are built to a height of 35 ft. from the foundations, and the brick inverts of the locks are approaching completion. The inner lock, 217 ft. long, is absolutely finished. The total length of the lock is 600 ft., and the width 75 ft. from cope to cope. At the entrance to the lock the river walls are being constructed of prodigious strength, for the base is 36 ft. These walls are designed to extend 250 ft. beyond the lock entrance, forming a tidal basin. The dock itself is 1,400 ft. in length, by 500 ft. in width, and the total water area, including the lock, nearly 17 acres, but this is exclusive of the tidal basin just alluded to. The dock wall is 47 ft. high from the foundation, and 22 ft. thick at the base. Of this wall about half has been constructed, and the remainder of the masonry is being vigorously pushed forward. In order to give an idea of the great extent of the entire undertaking it may be mentioned that the total excavations, including the approaches, will amount to two million cubic yards, of which about four hundred thousand cubic yards remain to be excavated. It is remarkable that notwithstanding the great depth of the excavations in order to secure the foundations of the lock, which are 13 ft. below the bed of the Avon, very little pumping has been required; for there are only two steam pumps on the works, and only one of these is in constant use. There is no doubt that when completed the Avonmouth Dock will be one of the finest in the country. The quality of the work is deserving of all praise, and no dock in the world will have finer ashlar stone used in its construction. The lock is the largest in England."

PEDESTALS AND FEET IN ANCIENT ART-INDUSTRY.

By Prof. Dr. Stockbauer.[1]

THE exquisite creations of antiquity, and the successful products of its art-industry, can never be brought too often to the memory of the manufacturing artist, or too strongly impressed upon it. Still, the value of these models must not be taken to consist in their furnishing examples for a stolid and uninventive imitation, but in their giving illustrations of certain art principles and the manner of their application. The period of Louis XIV. and that of the Pompeian wall decoration of the nineteenth century, will never obtain universal recogni-

[1] In the Stuttgart "Gewerbehalle," No. 6, 1874.

tion. They are still-born, and life cannot be breathed into them. They want the conscious, intelligent obedience to the laws of style exercised by the ancients; and this conscious obedience is the only means possible for drawing any profit from the models bequeathed us by ancient art. To help a little in this direction, we bring before our readers a single development of ancient art-industry, that named in the title of this short article, and shall attempt to elucidate the laws of style of which this development furnishes an illustration.

Glancing in the first place at the moulding of vases, the foot may be observed either as forming an integral part of the vase or as being more independent of it, and forming a pedestal. In either case, the foot has its own peculiar form, clearly indicating its place and purpose. In the first case it is formed as an annular foot, in straight or swelling lines, and connected with the body of the vase by a band wrought in the design, or indicated by colour (figs. 1, 2, 3, 4). It acquires a further development through a concave moulding, which is inserted between the lower ring and the body of the vase, and recalls the trochylus of the base of an Ionic column, although assimilating, in its lower part, to the formation of the foot (figs. 5, 6, 7). The absolute inseparable conjunction of body and base is clearly enough expressed by the art symbol of a band or a torus.

When a base is meant to have more independence its relations alter. Its design is not all downwards, but indicates an effort to compete with the vase itself, as an independent supporting member of it. Its simplest, theoretic form is the shape in fig. 8, of the cylinder spread at top and bottom. In an artistically perfect form this pedestal has its own peculiar finish at the upper part, a corona, which, however, with regard to its relation to the cup becomes a cyma, that art symbol which is invariably used to typify that the part crowned by it is separate and independent, but in conflict with a part lying above it (fig. 9). If this tall foot or pedestal is lengthened, these simple forms are more richly featured, and its twofold tendency, in particular, is more clearly brought out by a line of separation, a corona, or a band, which according to its nature joins these lines, those ornamental as well as those characteristic of upward and downward direction (figs. 10, 11). Almost all model examples of the plastic art of antiquity are distinguished by the correct use of the cyma, and it is an essential part of the grammar of antique ornament. If we now look, for the sake of example, at the ancient altar in fig. 16, we shall see that, as a whole complete in itself, it is terminated at the top by the well known wave pattern. But if a similar construction be used, not as an isolated and complete whole, but as the pedestal for a statue or the base of a column, the decoration of the upper part changes in accordance with the change of use; instead of the separating finish above, a cyma is inserted, by means of which the independence of the base of the column, and its function relative to the column, are harmonized (fig. 17).

The influence of laws of design, shown to be so potential in the simple forms of the pedestals of vases, is equally pervasive in the various configurations adopted from the feet of animals; these laws may be summarized under the three heads following:

1. All such feet must be kept in the strictest subjection to the architectonic thought which is the principle of the whole.

According to this every individuality of form which does not contribute to the ruling thought of the whole is excluded. Under certain circumstances a table may be made to stand upon stags' feet, or a centrepiece upon hares' feet; but if these feet were made use of in their naked reality of hair and skin, they would appear as motiveless and solitary individualities, which had been placed in repulsive and revolutionary opposition to the design of the whole. And the same is also the case when such feet are so modelled and wrought as to make but a chance set of insignificant objects, which have no correspondence with the idea of the service prescribed them by the architecture.

2. All supports in the form of feet, imitated from nature, must correspond to the purpose served by the whole.

Things essentially stable in character, if set out with feet designed after nature, must have them brought into connection with the ground by a plinth. The omission of this indication of architectonic junction gives the whole the character of absolute mobility, a peculiarity which in a street lamp, for example, is entirely out of place. Articles of furniture, and other moveable objects, should have feet chosen for them appropriate to their respective degree of mobility. The Assyrians, who set their thrones on lion feet and their common chairs on gazelle feet, undoubtedly wrought according to the impression made by their conception of these animals respectively.

3. In the third place, feet imitated from nature in articles of furniture, or other objects to which such feet are appropriate, must not be presented otherwise than as they appear in the living original.

The feet of animals must be in a state either of action or rest. Their active energy, walking, leaping, &c. cannot be turned to any architectonic account, since leaping, walking, &c. are not looked for from our implements and furniture. However mobile an article of furniture may be in its use and character, it must in our service be at rest. In the position of rest the feet of animals present two views:—1. that of the animal lying, the hind legs with the double broken lines, and the forelegs, which with a slight bend support the upper part of the body; and 2, the sitting posture, the feet being almost vertical (fig. 12). We find both forms copied in ancient art. The short foot of the candelabra has the first as its prototype (fig. 13), the high foot in tables and implements the latter (fig. 14). In both designs, however, absolute repose is an essential and not casual peculiarity. In all ancient art it is precisely this "classic repose" which predominates. The caryatid bears up an entablature to all appearance as painlessly as a column would; and although later on an appearance of muscular effort and endurance has been given to these anthropomorphic pillars, it seems to have been forgotten that Pozzo, without, it is true, wishing to do so, has made the whole category of these stony endurances ridiculous by his invention of the curved column. The column, such was his conclusion, supports the architrave; the human figure in a similar case finds the weight heavier and bends, but columns are often replaced by such bending supports, therefore the column may also have a deflected form (fig. 18).

The sound and clear views the ancients had of nature made it repugnant to them to fashion implements or furniture after the model of creatures groaning and exhausted under the weight of a disproportioned burden; and even equilibristic objects of art were scarcely known to the artists of antiquity (fig. 15). Their creations thus acquired that cheerful placid character which the present age, however much it admires it, cannot win to itself. They compensated the monotony of such repetitions of straight lines by their skilful composition, and by this means stamped upon the poorest implement the impress of a work of art, and of its conformity to their plastic ideal.

That such upright feet were probably composed under the direct influence of the contemplation of the animal form in repose is further indicated by the circumstance that the head of the animal was added on to the elongation of the foot, in such a way, that at a little distance there seems to be a fugitive silhouette of the fore part of the body of the animal so at rest. The head crowns the foot, but does not support the table; since, indeed, it would be contrary to all propriety to use for such an humble purpose the very part of the body which does not support any thing, and which answers all fitting purposes as a completion of form. The table is preferably supported upon prolongations of the foot, which are of such a height that they are themselves covered by the shadows thrown down by the table-top, while the heads remain in sight over the feet (fig. 19).

We could easily point out a great number of peculiarities in the foot-figures employed in ancient art-work, which seem at the present time to be but little understood. Our foregoing remarks, however, may perhaps suffice to induce a thinking and earnest artist or two to seek into the intellectual treasures contained in ancient art, and to appropriate, not its lifeless form, but the true apprehension of its nature. If the Latin proverb "Poëta nascitur, rhetor fit" be true, an analogous application of it to plastic art is also true: Nature makes the artist, but whoever wishes to become an art-workman capable of any worthy performance, must study.

SUBAQUEOUS ENGINEERING.

By F. J. Bramwell, C.E., F.R.S.

THERE is properly included under the title of "Subaqueous Engineering," not only those works which are really executed under water, the water not being even temporarily removed, but those other works which are carried out in places that were covered with water before the works were commenced, and that will be again covered with water after the works are completed, although during the time they are in execution the water is removed, and the place where the work is being carried on is laid bare and is kept dry; and thus it will be seen that "Subaqueous Engineering" embraces a vast number of cases, such as canals, docks, quay walls, locks, breakwaters, harbour, bridge, and viaduct foundations, and frequently shafts for collieries and mines.

Looking at the vast extent presented by this view of our subject, I am aware that the title "Subaqueous Engineering" is far too

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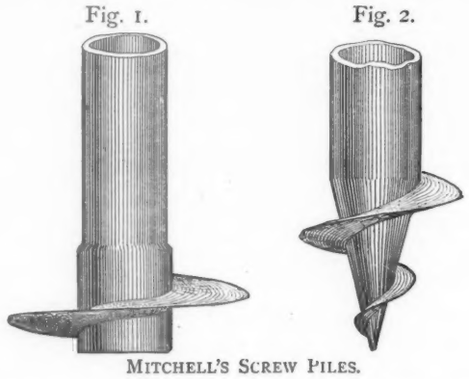
comprehensive for a single paper; but in selecting my title I was in this difficulty; either I must employ a concise but too comprehensive one, or I must use a title which, while it really defined the branches of "Subaqueous Engineering" on which I intend writing, would inevitably have been in itself too long, and probably after all too complex and obscure. Of the two evils I thought I would choose the lesser, and have the concise but somewhat pretentious "Subaqueous Engineering."

Now, although the necessity of a good foundation is a matter so obvious as to have passed into a recognized figure of speech, and although the professional engineer knows that the most anxious part of his labours are those which are connected with foundations, yet I think it must be admitted that the general public pay little heed to the question. Some magnificent bridge or railway viaduct is designed across a wide river or arm of the sea, and when it is finished that which is above the water is seen and appreciated by all, but that which is below is out of sight and is out of mind. During the execution of the works those who passed by may perhaps have noticed that for months, or even for years, there were dotted about in the wide expanse of water a few ungainly-looking timber stages, carrying small portable engines; that to those stages the workmen resorted, disappeared within their enclosures, and as far as the mere spectator could tell, did but little when they got there, for from week to week and month to month nothing more was to be seen than the apparently rude timber frame-work. But to their cost the engineer knows, and the contractor knows, that within those enclosures a great fight was carried on against all natural obstacles, a fight which was to result in defeat or triumph—and I am glad to say in almost every instance the battle has resulted in triumph for the engineer—and such men know that within those enclosures there had been inch by inch constructed the foundations upon which the glorious superstructure, the superstructure as seen and admired by all, was eventually to rest—foundations without which it is idle to say that superstructure would have been an impossibility.

I do not propose to occupy space by a detailed description of the simpler modes of executing subaqueous works and foundations; I must pass many by without even mentioning them, and to others I must devote the very briefest notice.

The method of making foundations by "piling," for instance, I will pass by, although there is much of interest in the ingenious contrivances which from time to time, within the last fifty years, have been invented and brought into use for the purpose of driving piles, including steam machinery, pneumatic machinery, and, quite lately, gunpowder. I will also dismiss in the most summary manner the mode of laying bare a portion of a river-bed by enclosing it within a coffer-dam, ordinarily made of two

Fig. 1. Fig. 2.

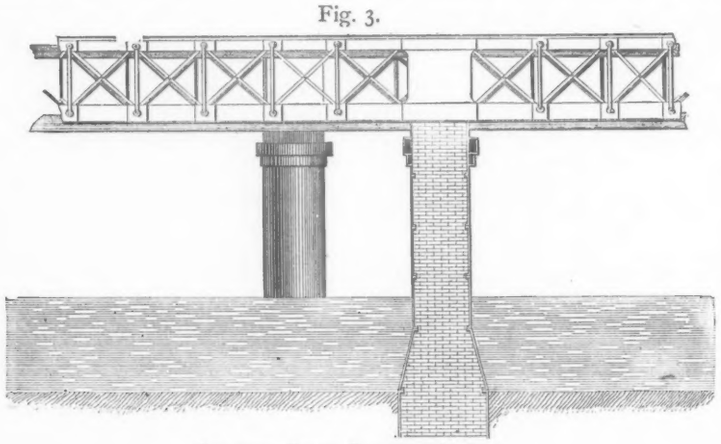


MITCHELL'S SCREW PILES.

rows of close piling, the rows being placed a few feet apart and filled in with puddled clay, so as to make a continuous water-tight wall surrounding the part to be laid dry; and thus, when pumps are applied, the water can be removed and the workmen can deal with the exposed river-bed as they would deal with ordinary dry land.

I will content myself as regards this part of the subject with simply referring to an extremely simple form of pile, invented about forty years ago by Mr. Mitchell, and now well known among engineers as the "Mitchell" screw-pile. Its very name

Fig. 3.



CHARING CROSS RAILWAY BRIDGE.

describes its construction, and I have therefore only to call attention to figs. 1, 2. It will be seen that the pile consists of a gimlet-pointed central spindle (the pile proper), provided with a large flat screw disc. The pile is placed point downwards upon the river- or sea-bed, and, being properly guided, is turned by capstan bars, and screws its way into the soil until the desired stratum or depth is reached by the disc, and there it remains, competent to bear a heavy load, and equally competent to bear great upward strain. It is this latter property that has made these piles so valuable as a means for securing moorings in rivers.

I will also pass over most briefly those most useful—in fact, in many cases indispensable—adjuncts to subaqueous engineering, the diving-bell and the diver.

The invention of the diving-bell is commonly attributed to Halley, but he was not, and did not lay claim to be, the inventor—simply the improver, but a most material improver.

In his paper in the "Philosophical Transactions" he refers to the diving-bell as being a well-known implement, in which, according to the size of it, men could exist for a certain time under water. But prior to Halley there were no means by which the air within it could be renewed, nor were there, either, any means by which a sufficient volume of air might be introduced in the outset, to compensate for the compression of the original volume which must take place when the bell is lowered into deep water. In 1716, however, Halley made the diving-bell a really useful machine, by devising a means—a very ingenious one—for supplying it with fresh air. This means was also applicable to filling the whole volume of the bell with air. He effected this by means of two 36-gallon casks, coated with lead so that they would sink, although empty, and provided with tackle to raise and lower them alternately. Care was taken that the casks should always go with the open bungholes downwards. From the top of each cask a waxed leather hose proceeded, which hung down by the side of the cask, with its mouth below the bunghole. Matters being thus arranged, the cask was lowered full of air, the air was compressed in the cask according to the depth by the influx of water through the bung-

hole, and the cask being guided by cords to the neighbourhood of the bell, the workman in it seized the hose, and bringing its end into the bell, the volume of air from the cask was transferred to the inside of the bell. In this manner, Halley says, he was enabled to thoroughly supply the bell with air, and that he himself formed one of a party of five who remained in from nine to ten fathoms of water for one and a-half hours, without the slightest inconvenience. It was not until more than seventy years afterwards—viz., in 1788—that the celebrated Smeaton perfected the diving-bell by substituting the use of compressing air-pumps to supply the bell through a hose in lieu of the casks of Halley. Divers fitted with some kind of helmet appear to have been known quite as early as the diving-bell itself, but the great development of this mode of working under water has been made since the improvements in india-rubber fabrics. As is well known, the modern diver is clothed with a waterproof and air-tight dress, and is supplied with air directly to the helmet which covers his head, the escape of the air at a

Fig. 4.

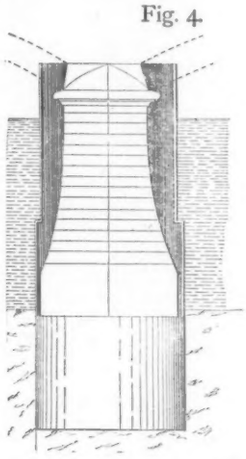
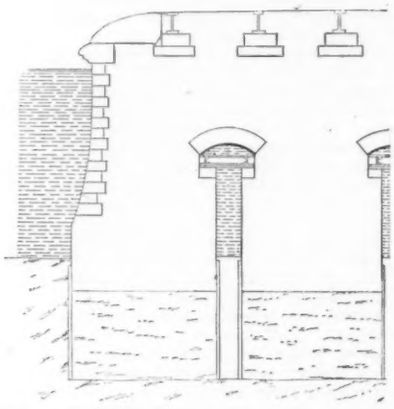


Fig. 5.



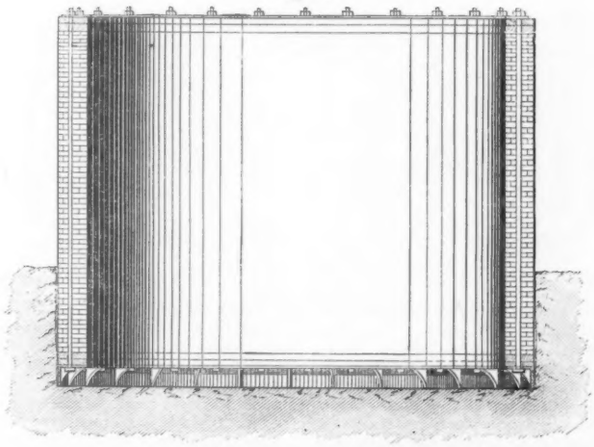
VICTORIA (BATTERSEA) BRIDGE.

pressure slightly above that due to the head of water being made through a valve.

Very many important engineering works have been carried out by the aid of the diving-bell and diver; but it would be tedious and useless to attempt to enumerate even a tithe of them. It will suffice to call to mind one of them, viz., the Dover pier, which, so far as regards the subaqueous portion, has been constructed entirely by the aid of the diving-bell and diver.

One of my friends who has been largely connected with harbour works, tells me that his resident engineer made an unfair use—at least it appears to me an unfair use—of his diving dress, for he availed himself of it to select and catch the best lobsters that he could find at the bottom of the sea; and as a

Fig. 6.



THAMES TUNNEL SHAFT

further proof how comfortable men in diving dresses may be below the water, and how amphibious they become, I may mention that the resident engineer of a well-known bridge discovered the slow progress of the foundations, which was causing him much anxiety, arose from the divers finding themselves so very much at home below the water that they took their ease there, and discarding hard work, occupied themselves with games of subaqueous cribbage.

Having thus briefly dismissed some of those modes of carrying out subaqueous work, which I feel are too well known to justify me in occupying more space with them, I must pass by without a word many other subjects that properly belong to subaqueous engineering, and will at once ask attention to certain special means employed in subaqueous works—means which, although probably heard of, may not be known in such detail as to enable one to judge of their ingenuity and merit.

One of the most ordinary modes in which at the present day foundations of bridges are executed, is by the employment of cylinders; occasionally, in fact commonly with railway girder bridges, the cylinders are continued above the water level and up to the superstructure they have to support. Instances of this are familiar to all. I will only call to mind two, viz., the Charing Cross and the Cannon Street bridges over the Thames.

Where, however, the bridge is an arched structure, and the arch requires abutments low down, the cylinders, although they are used for the foundations do not appear, as in such bridges the necessary support to resist the thrust of the arch permits of the employment of the usual stone piers above the water

level. These piers are built upon a platform, commonly of iron, which rests upon the tops of the cylinders.

The widening of the Victoria Railway bridge at Battersea over the Thames, and the Rochester Roadway bridge, are instances of this mode of construction.

The cylinders, whether they stop at the water level, or whether they are carried up to the superstructure, are generally of cast-iron.

The origin of the art of sinking cylinders of some material and for some purpose is, I believe I may say, unknown. Every one is aware that one of the commonest modes of making a well is to prepare a wooden curb, to place it within the excavation, to line it with brickwork, and then to continue the digging, the curb with the brickwork sinking down to protect the sides of the well, the curb being added to as it sinks.

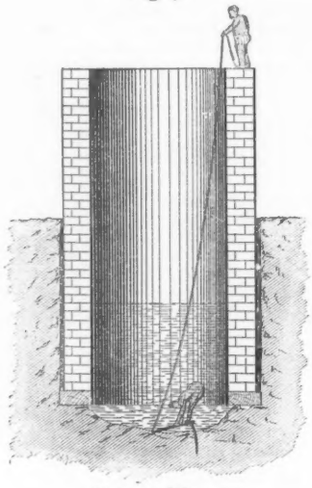
The celebrated engineer, the first Brunel, availed himself of this method to sink the shafts of the Thames Tunnel. The ground being levelled, he placed upon it a cast-iron ring, provided at the outside with a cutting edge, and on this ring he built in brickwork in cement the wall of the shaft. This wall was 3 ft. thick, and was carried up as a tower 40 ft. high before the excavation for the shaft was commenced. Vertical tie-bolts at frequent intervals were built into the brickwork, these extended from the base ring to the top of the brickwork, so as to hold it all together.

The excavation was then begun, and the whole structure sunk slowly; as it descended more and more brickwork was added to the top, until the full depth of 80 ft. was reached. The external diameter of the brickwork was 50 ft. The sinking of the Rotherhithe shaft was begun in February, 1825, and completed in eight months.

In India, the natives have, from time immemorial, availed themselves of this mode of sinking cylinders, and have used the cylinders for the foundations of their bridges.

This is an instance where necessity has led to invention. Many Indian rivers have beds composed of sand and shingle extending down to a great depth. These beds are all but dry for many months in the year; but during the rainy season, are swept by torrents so impetuous that they commonly excavate new

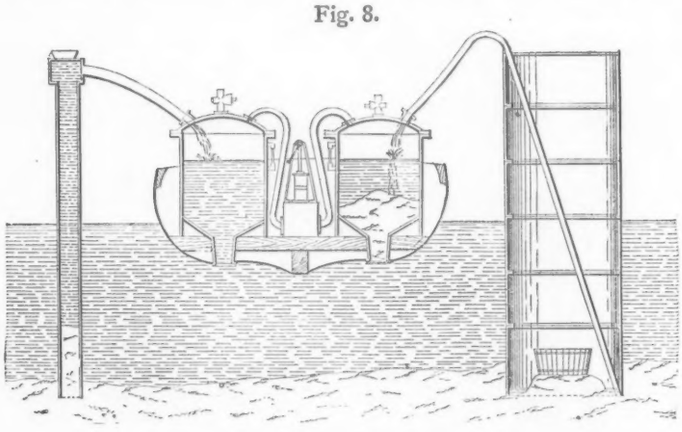
Fig. 7.



INDIAN WELL.

and deep channels in the sandy soil, and thus the bridge-builder who erected his piers upon that which, at the time, seemed to be not only a firm but a durable shingle foundation might, after the

Fig. 8.



POTTS' PNEUMATIC SYSTEM.

next rainy season, find that the torrent had selected that particular portion of the river as the place in which to scoop out a deep channel, and thus the foundation which he had put down, although he might have put it several feet below the surface, would be undermined and washed away. It was this fact which drove the native builders to carry their foundation down below the lowest point to which channels were ever cut, and this, as I have said, they effected by means of brick cylinders built upon curbs, very much as our well-sinkers built them, and then the workmen got within the cylinders and excavated as far as the water would permit, and after this point was reached, an ingenious instrument called a "Phoura" or "Tham" was employed. This, as will be seen on the diagram, was a sort of powerful spade attached to a rope; it was lowered to the bottom of the cylinder, and then a diver went down and forced the tool as far as he could into the soil. After his ascent, the workmen above hauled on the rope, and thus dug out and brought to the surface the shovelful, and by a repetition of these operations the cylinder, being properly weighted, was got down to the desired depths. These cylinders were placed quite close together, and upon them the upper part of the pier was built.

Although, in order of date, the invention of the celebrated Earl of Dundonald (then Sir Thomas Cochrane) in 1830, ought to be taken first, I find I shall be enabled to deal with his invention, and with the great works which have been of late years executed under it, if I deal with his invention and with these works consecutively; and therefore, to prevent a break in the account of them, I will at this part of my paper refer to the ingenious plan invented by Dr. Potts, in 1843, and to the equally ingenious mode devised by Mr. Brunlees, about 1856.

Dr. Potts proposed to employ tubular piles (of cast iron), which were to be open at the bottom and temporarily closed at the top. A connection was to be made by means of a flexible hose from a branch in the closed top of the pile to an exhausted receiver, the connection being controlled by a cock. The result of this arrangement was, that when such piles were placed in sandy or even gravelly soils charged with water, and the connection was made between the interior of the pile and the exhausted reservoir, the pile rapidly went down to such a depth as was sufficient to enable it to resist afterwards a permanent heavy load. I have heard eminent engineers, even within the last few years, state that the sinking of the piles by Dr. Potts' process, was due to the pressure of the air upon the top of the pile. But as by this process small piles of only one or two feet in diameter were sunk, and the pressure of the air upon a one-foot pile, even assuming that total vacuum were obtained, could never exceed 15 cwt., it is manifest that the pressure of the atmosphere must play a wholly insignificant part in the sinking of the pile. If a weight

of 15 cwt. bearing on the top of the pile would sink it, then it is obvious the pile would be but of little use to support a load.

The true explanation of the way in which the exhaustion of the air sinks the pile is, I think, not far to seek, as will appear upon the consideration of the following statement.

I have said that piles in order to be sunk by this process must be in a soil containing water. Now, assuming, as in the diagram, a pile to have been driven by some means a little distance into the soil, and then assume that the air is exhausted from the pile, the pressure of the external air will tend to drive up the water into the body of the pile, and to do so with great violence.

The strength of the current of water will manifestly be close to the bottom edge of the pile, and this current in passing will sweep before it the particles of gravel and sand upon which the pile has been standing, in fact the current digs the soil away, and I think it will be found convenient if we identify this action by giving it the name of "hydraulic digging." The weight of the pile, and to some extent the pressure of the air, urging the pile constantly downwards, and the support being removed from below, the pile will sink, and will continue to sink so long as the current is kept up below its bottom edge, unless, indeed, its progress should be arrested by meeting with some obstacle, or by the friction of the soil upon the sides.

The liability to stick was the difficulty in the Potts' process, for if the weight of the pile and any load that was put upon it plus the atmospheric pressure were not enough to overcome the friction, then the pile did not sink very far, although the water rushed into the inside and brought a large quantity of matter with it, thus filling the pile. When this happened it became necessary to withdraw this material from the interior of the pile, and to make a re-application of the pneumatic process. As I have said, the plan was highly ingenious, and it was applied to some extent; among other places in one or two instances for the foundation of bridges on that part of the Chester and Holyhead line which crosses the Isle of Anglesey.

This system was also employed in a bridge over the Nene, in the Black Potts Bridge, near Windsor, and in a bridge over the Shannon, and in Cornwall it was used at the Wheal Ramotts mine to sink a shaft through the sea.

Another mode not only of sinking piles but of making piles, was invented and has been carried out by Mr. Brunlees, the engineer. This mode, like that of Dr. Potts, is peculiarly applicable in sandy soils, and has been largely used by Mr. Brunlees in the viaducts of the Morecambe Bay Railway and in the Southport pier and elsewhere.

The piles, which are hollow cylinders of cast-iron, are made, as will be seen in the diagram, with large bottom discs, having a diameter about three times that of the column. This disc closes up the bottom of the column entirely with the exception of a central hole (about 2 in. in diameter), into which a pipe is inserted. The pipe rises through the pile, and its upper part is attached to a hose connected to some source of water supply under pressure. The disc at the bottom of the pile is furnished on its under side with a number of radiating strips or plates.

The disc being placed upon the sand, and the pile held upright by steadying ropes or guides of some kind, water is passed

Fig. 9.

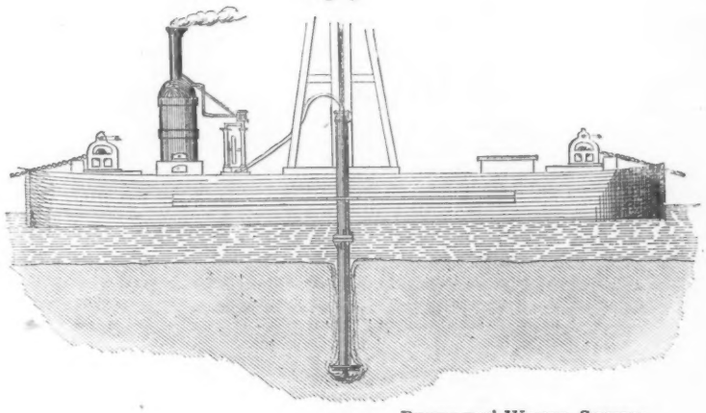
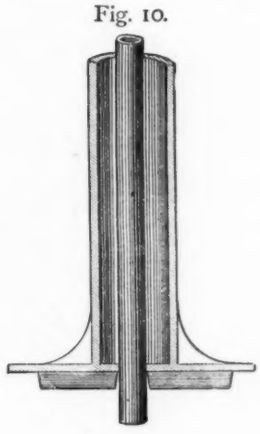


Fig. 10.



BRUNLEES' WATER SYSTEM.

down the 2-inch tube; this water has to escape from below the disc, and endeavours to do so as near to the edge of the disc as possible, and finding the radial feathers close to the orifice of the pipe, the current is distributed along the channels between the feathers, so that the water escapes with tolerable uniformity all round the edge of the disc. This water current, as in the Potts' system, digs away the sand immediately below the disc, and drives it up past its edge, and then the current becoming resisted deposits the sand upon the top of the disc; being free of all support from below, the pile sinks. The water that had issued out finds its way up close round about the shank of the pile, thus keeping the whole of the sand round about that shank "alive," and preventing lateral friction.

In practice, by the employment of this method, piles have been got down at a considerable velocity, but as soon as the current was stopped they were found competent to bear the necessary pressure. Further, by the aid of the current, piles that have been improperly placed can also be removed: it is only necessary to turn on the water, and to leave it on for a sufficient time to put the sand above the pile into motion, and thus to get rid of the lateral friction, to enable the pile to be readily drawn out.

It will be seen that the method pursued by Mr. Brunlees depends for its success upon that which I have called, in Dr. Potts' case, "hydraulic digging;" and it may perhaps be interesting to allude to an instance in which the power of a jet of water is used in the open air to effect digging.

In California, water is brought from great distances, under the pressure due to the elevation of the source of supply, and is let out to the miners at a certain rate according to the quantity they use. Jets of this water under pressure are employed to bring down the conglomerate cliffs, which are washed to obtain the gold. This is done by directing a jet of water against the under side of the face of the cliff, and in that way a cavity is cut out along the bottom, as coal is "holed" in the coal mine; the cliff being thus undermined, falls down and breaks up into large masses, which are again reduced by the further use of the jet upon them.

This is, as I have said, an instance of hydraulic digging, pure and simple.

I shall have occasion, when speaking of the St. Louis' Bridge, to revert to the great use that may be made of powerful water jets for the removal of obstructions.

The two modes I have described, namely, those of Dr. Potts and of Mr. Brunlees, which operate by hydraulic digging, are perfectly applicable to passing through sandy soils, or even uniform soils of light or regular gravel; but it is manifest that this plan of hydraulic digging could not be sufficient in those cases where sandy soils alternate with beds of clay, or where sandy soils abound with boulders or other matters which would interfere with the flow of the material in obedience to the water current. This difficulty it was that prevented the use of Potts' system at the Rochester Bridge.

It was originally intended to employ Dr. Potts' method to sink the cylinders for the piers and abutments of that bridge, but on going to work it was found the trial borings had failed to detect that the foundations of some old structure were in the way, and that the Potts' process could not possibly be applied.

Some plan had to be resorted to that would admit of access being obtained to the soil at all times, as the cylinders were sunk, so as to enable the soil to be dealt with by the usual methods of excavation. It was under these circumstances that, about the year 1850, it was finally determined to make use of a pneumatic process—not the exhaustion process of Dr. Potts,

but a pressure process, one by which the water might be driven out of the cylinders, and thus the bottom might be laid and kept bare. Although the first application in England, so far as I know, of this system was, as I have said, at Rochester Bridge, in the year 1850, the credit—not merely of the idea, but of the details of carrying out the idea—is due to a man celebrated, not only for the greatest personal bravery and hardihood, but for many ingenious inventions.

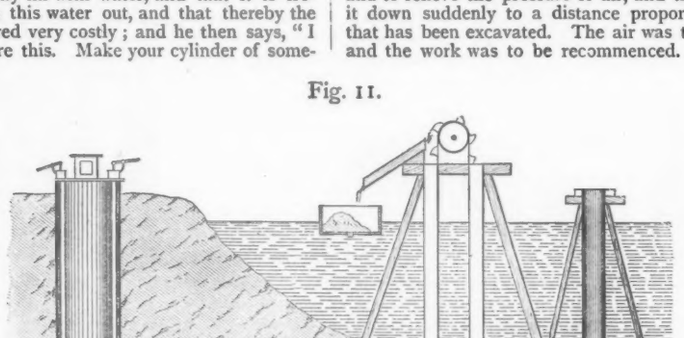
I allude to Sir Thomas Cochrane, better known as the Earl of Dundonald.

In 1830 Sir Thomas Cochrane, having applied his mind to the subject, induced to do so by the difficulties that were then being encountered in the execution of the Thames Tunnel, succeeded in devising a complete system of cylinder sinking, carried out by the pneumatic pressure process, a system which is now most largely followed in engineering practice, and a system which has been greatly developed, especially in America.

Fig. 11 shows that which Sir Thomas Cochrane, now forty-four years ago, invented; and I say unhesitatingly that the description in his specification is so full and clear that any engineer might, even in those days, by the mere perusal of it have been instructed in all that was necessary to enable him to carry out cylinder foundations by the pneumatic pressure process, as they are carried out at this very day. Sir Thomas Cochrane points to the fact that cylinders when made in brickwork sunk in wet places speedily fill with water, and that it is frequently difficult to pump this water out, and that thereby the work of sinking is rendered very costly; and he then says, "I will show you how to cure this. Make your cylinder of something air-tight and competent to withstand an air pressure. Make it of cast-iron;" and he proceeds to give directions how a cylinder is to be made in sections, bolted together internally, so as to present a smooth surface on the exterior. Then he says, "Put that cylinder upon the earth that you wish to excavate; get inside and excavate. The weight of the cylinder will carry it down, you taking the precaution to make the lower edge a cutting edge, and so you will go on, as in a brick cylinder, to the point where you meet with water." Then he says, "Instead of endeavouring to obtain access to the bottom by pumping out the water at a greater rate than it can flow in, obtain access to the bottom by the expulsion of the water by pressure, and not by endeavouring to master it by pumping.

"To do this you must close the top of the cylinder, and then, by injecting a pressure of air equal to or a little greater than the head of water that is surrounding the cylinder, any water that is in the cylinder will be driven out round about the bottom of it, and all other water will be prevented from entering." He further directs that if the cylinder is not in itself heavy enough to withstand the upward pressure of the air and to force the cylinder down as the excavation proceeds, it must be properly weighted; and he points out that in cases where the depth is great, and where the pressure of air that must therefore be used would tend with great force to raise the cylinder, it may at intervals be necessary to withdraw the men from the cylinder, and to relieve the pressure of air, and then its weight will send it down suddenly to a distance proportionate to the amount that has been excavated. The air was then to be re-admitted, and the work was to be recommenced. Now, many inventors

Fig. 11.



EARL DUNDONALD'S AIR-PRESSURE SYSTEM.

—mere inventors, and not men who followed up their inventions into detail, as Earl Dundonald did—would have stopped here, would have left to others the task of perfecting the practical application of their inventions; but Earl Dundonald did not follow this course, he went on into the requisite working details, and one of the first things that occurred to him was that if a pressure of air were maintained within a closed cylinder, the workpeople could not get in or out, and that in that way there would be a difficulty. This he provided for by making that which is now well known as the "air-lock." By this contrivance he was enabled to overcome the difficulty in the same way that a barge is got from the low level of a canal up into a higher level, and against, therefore, a higher pressure of water; for so it really is. By means of a lock he provided for the admission of workmen from the external air at the mere barometrical pressure to the internal air of the higher pressure requisite to balance the column of water contained in the earth.

Referring to his specification, it will be found that he provided that which he calls an antechamber furnished with two doors, the one leading from the external air into the antechamber, the other leading from the antechamber into the cylinder; both these doors opened inwards. The mode of using such an apparatus is pretty obvious, but it may perhaps be well to describe it.

If the inner of the two doors, the one leading to the cylinder, were shut, the outer one, that in connection with the atmosphere, might be opened, and the pressure in the antechamber would be that of the atmosphere. The workman then enters the antechamber, closes the door by which he has passed, then opens a cock, the equivalent of the sluice in the water lock, which lets in some compressed air from the cylinder, and thus fills the antechamber with air of the same pressure as that which is prevailing in the cylinder itself. As soon as this equality of pressure is established, the workman finds no difficulty in opening the inner door, by which he obtains access to the interior of the cylinder. Similarly on leaving, it is only necessary to get the pressure in the antechamber to equal that in the cylinder, then to pass from the cylinder to the antechamber, close the door of communication between the two, open an outlet cock (again the sluice of the lock), allow the surplus pressure to escape into the atmosphere, and thus admit of the external door being opened, and of access to the outer world being obtained. The attention of Sir Thomas Cochrane to detail went, however, beyond this device of the air-lock, for he foresaw that it would be convenient to have the means of removing the material excavated, and of introducing bricks and other matters without the trouble of working the air-lock, and he invented a plan by which an endless chain furnished with buckets, such as are used, on a large scale for dredging barges, and on a small scale for the elevating of corn and meal in flour mills, might be employed for the removal of the excavated material to the outer air, and without any escape of the compressed air within the cylinder, notwithstanding that the internal pressure might largely exceed that of the atmosphere; and he accomplished this by the employment of a tube, or of two tubes, having their mouths lower than the level of the edge of the cylinder, a place being provided for these mouths by making an excavation deeper than the general excavation, so that the mouths might be covered or sealed by water. In this manner the interior of the tubes is filled with water, in the way in which a barometer tube is filled with mercury, and through the water the chain of buckets can operate without loss of air.

By this contrivance the workman has simply to shovel into the hole under the water the excavated earth, and the buckets as they slowly come round seize it, and elevate and deliver it con-

tinuously into barges or other receptacles above. For the mere introduction of materials, Sir Thomas Cochrane showed that a plain tube with its mouth similarly sealed was sufficient, and that bricks and materials of that kind, which would not be injured, might be thrown down the tube through the water, and other matters might be lowered through it.

Thus it will be seen that Sir Thomas Cochrane, in addition to suggesting the construction of metallic air-tight-cylinders, and the keeping out of the water by pneumatic pressure, elaborated too the very details by which men and materials might, at all times, be introduced, or might be withdrawn from or leave the interior of those cylinders. Furthermore, Sir Thomas Cochrane pointed out that there might be instances in which the depth and consequent pressure would be so great as to be injurious to those who were to work in it, and he therefore suggested that his invention might be used half-way as it were in mitigation of the ordinary difficulties, and that if, for example, a depth say of 100 ft. was to be reached, and that it was only desirable to work in an air pressure equal to 50 ft., that even then that had better be employed than no pressure at all, because although pumps would have to be used to extract the water which would then flow in so far as was represented by the unbalanced pressure of 50 ft., it would come in much more slowly than if it came in with the pressure due to 100 ft., and that thus a smaller quantity of water would have to be pumped out, and less power would be required; in fact it might be that streams of water, which would be so copious under an unbalanced pressure of 100 ft. as to overcome all practicable pumping power, could be kept down when flowing in with the diminished velocity due to a differential pressure of only 50 ft.

I feel I have given too much space to Sir Thomas Cochrane's invention, but I have done so because, as I have said, we owe to him not alone the idea of making use of compressed air, which I believe would have been by itself sufficient to have entitled him to the gratitude of every engineer, but we owe to him the perfecting of the details for the carrying out of his invention.

Sir Thomas Cochrane was before his age, and so far as I know no attempt was made in England to put his invention into practice for more than twenty years. I believe the first application of the compressed air system was made in the year 1839, when two French engineers, Messrs. Triger and Les Coses, having to sink a shaft through an extremely treacherous water-bearing soil, in fact through a place which at one time had been a part of the bed of the Loire, resorted to the process of pneumatic pressure cylinder sinking. I do not know whether or not these gentlemen were acquainted with Earl Dundonald's invention; but whether they were or were not, I believe that to them the credit is due of having first put the plan into practical operation.

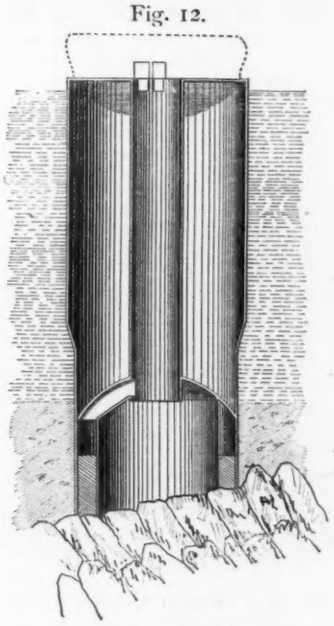
Before doing so, they however most properly tried to inform themselves upon some points on which they were in doubt, and among these were the power of the human frame to support great atmospheric pressure. I should have thought that the information obtainable in the case of diving-bells would have been sufficient to have set their minds at rest; but it seems they did not think such information was sufficient, and they adopted other means in order to satisfy themselves. It appears that even so long ago as the year 1839, a physician in France had suggested that beneficial results might be obtained in certain cases of pulmonary complaint by subjecting the patient for some time to a compressed air bath, and in Paris such a bath had been erected. It would seem that for this purpose a pressure never exceeding a few pounds above the atmosphere had been employed, and that pressure was obviously not sufficient to satisfy the inquiries that Messrs. Triger and Les Coses were then instituting. They, however, obtained permission to experiment with the air baths, and one of them, M. Les Coses, entered within the bath, while his friend kept watch outside. The pressure was gradually increased up to 20 lbs., when suddenly the experiment was terminated in a manner which, to the experimenter within the bath was at the time sufficiently alarming. He states that as he sat there watching the effect the compressed air produced on him, and taking notes of all that occurred, he suddenly heard a loud report, found himself in total darkness, and was very nearly frozen to death. All these alarming incidents were, however, attributable to a very slight cause. The side of the bath was fitted with a plate-glass window that was sufficiently strong to endure any pressure to which the physician's patients had ever been subjected, but was not sufficiently strong to endure the pressures to which the engineers intended to go, and thus it was that in the midst of the experiment the pane of glass burst, the compressed air rushed out with a loud report, the escape of such a large body of compressed air instantly lowered the temperature, and the lowering of the temperature condensed the vapours into a thick fog, and in this way the experimenter, as he says, found himself in pitch darkness, and all but frozen to death. The experiment, however, was resumed, and the results satisfied Messrs. Triger and Les Coses that there was nothing to apprehend on the score of danger to health from the pressure of air that would be requisite in the workings in the Loire. Operations accordingly were commenced, and a wrought-iron cylinder 4 ft. 4 in. diameter was sunk.

It was provided with a double top in which were doors for the air-lock, and air was supplied by pumps worked by a steam-engine.

Pressure was applied with the happiest results in keeping out the water when it was reached, enabling the works to be carried on at the bottom with facility. In this manner the cylinder was successfully got down to a depth of 77 ft. With respect to the pressure of air therein employed its maximum must have been 33 lbs. A good deal was said at the time about its effect upon the persons who worked in it, and statements were made that some middle-aged men, whose lungs were to some extent affected, found themselves capable of working with much greater ease and vigour in the compressed air than in the ordinary atmosphere.

A few years afterwards (1845), another cylinder was sunk in France, at Douchy; here, unfortunately, a sad accident took place. After the works had been in progress many months, and

Fig. 12.



SALTASH BRIDGE.

when the cylinder was down to about 45 ft., the covers, which were made flat and of wholly insufficient strength, suddenly gave way and were blown up into the air, carrying with them the men who were working the windlass on the top, and causing indeed the death of some of them. This, as is usual in such cases, brought the system into temporary discredit, although really the disaster was entirely due to the want of common engineering prudence, in proportioning the shape and dimension of the parts to resist the pressures it was known must come upon them.

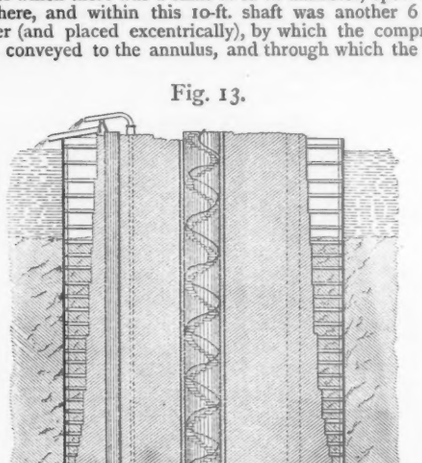
As I have already said, it was not until the year 1850 that Earl Dundonald's plan, published in 1830, was put to work in England, when it was employed at the Rochester Road Bridge after the failure of the Potts system to sink the cylinder upon which the two abutments and piers of this bridge were carried.

The cylinders were of cast-iron, put together by internal flanges; they were provided with air-tight covers fitted with air-locks; the water was expelled, and the bottom was laid bare by the pressure of the air poured into the cylinders. The success of this work was complete, and it was stated by the engineers that foundations which, executed in the ordinary way by the aid of coffer-dams, must have cost £73,000, were by the pneumatic pressure cylinder process got in for a cost of only £23,000.

The next instance to which I wish to direct your attention is that of the Brunel Saltash Bridge, which carries the Devon and

Cornwall Railway over the river Tamar, a short distance above Plymouth. The central pier of this bridge is in all 190 ft. high, from the foundation to the road level, and of this enormous height as much as 87 ft. 6 in. is below high-water spring tides. Trials had proved that at this the before-mentioned depth of 87 ft. 6 in. there was a good rock foundation, but there was nothing above it in the soil between the rock and the river bed which could be trusted to carry the noble superstructure. Mr. Brunel set himself to overcome the difficulty of getting in a foundation under such circumstances by an adaptation of the pneumatic-pressure process, and a wrought-iron cylinder, 35 ft. in diameter by 90 ft. deep, was provided for this purpose, but as the rock was known to be higher at one side than at the other, and as it was not deemed necessary to go to the expense of dressing the surface to a level over the whole area contained within the 35-ft. cylinder, accurate borings were taken, a model of the rock face was made, and the bottom of the cylinder was formed to suit. But as the air would escape from the high side of the cylinder, and thus it would be impossible to lay the low side dry, it was determined to make an annular chamber 4 ft. wide, and to divide this chamber by vertical air-tight partitions into eleven separate cells. The annulus was surmounted by a dome in the centre of which there was a shaft 10 ft. in diameter, open to the atmosphere, and within this 10-ft. shaft was another 6 ft. in diameter (and placed excentrically), by which the compressed air was conveyed to the annulus, and through which the workmen, by air rods, obtained access to their work. Arrangements were made by which the air could be directed into any one of the eleven vertical compartments, and thus the water could be driven out step by step all round the annulus, although the bottom was not level.

Fig. 13.



ST. LOUIS BRIDGE. CENTRAL PIER.

When the water was driven out the rock was dressed off, the cylinder was bolted down to it, and a ring of granite masonry was built within the annulus. It was hoped that this would be water-tight, and that the mud in the interior of the cylinder within the annulus might be excavated in the open, any leakage of water being kept down by pumping, but a strong spring broke out, and notwithstanding every effort, over-mastered the pumps. It was then determined to put the whole of the interior under partial pressure, and thus to master the water, partly by pressure and partly by pumping. This plan, it may be remembered, is among those given in Sir Thomas Cochrane's specification.

The next instance I propose to deal with is that of the foundations of the piers of the railway bridge near Strasburg, the Kehl bridge.

In this bridge the Saltash plan of having a diaphragm near to the lower end of the caisson was followed; but in the case of this bridge there was no provision of an annular chamber.

The piers were to be of large dimensions, and were to be built of stone; and it was determined not to carry them on columns, but upon a full-sized foundation.

The apparatus to be used, therefore, must be one large enough to enable a portion of the river bed, equal in size to the foot of the intended pier, to be dealt with.

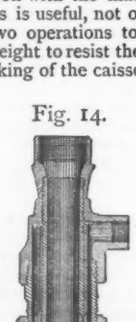
The German engineers feared that if it were attempted to carry this operation out in a single vessel, this vessel would be unmanageable, and they therefore determined to employ for each pier three separate rectangular vessels, placed side by side, the length of each vessel being equal to the width of the pier, and the breadth of the three vessels united being equal to the length of the pier.

In each vessel shafts of communication proceeded from the top of its diaphragm to a level above that of the water. Air-locks were established at the top of one of these shafts, while through another shaft—a water-sealed one—a chain of buckets, as suggested by Earl Dundonald, passed for the conveyance of the excavated material.

Two advantages attend the use of the diaphragm; one is, that being placed low down, the cubic contents of air to be kept under pressure are much diminished, and are thus brought within very manageable limits; the other is, that the permanent masonry of the piers can be carried on in the open air, and even during the time that the excavations are being proceeded with in the bottom chamber, because, as will be seen, the portion above the diaphragm being a water-tight wrought-iron structure, affords a chamber—in fact, a coffer-dam—in which the masonry can be built with the greatest ease in the dry.

This power of going on with the masonry while the excavations are still in progress is useful, not only because it expedites the work by enabling two operations to be carried on at once, but because it affords weight to resist the upward pressure of the air and to aid in the sinking of the caissons.

Fig. 14.



SAND PUMP.

I will now call your attention to two great works that have been carried out by the compressed-air system in the United States. I allude to the bridges over the Mississippi at St. Louis and to the East River Bridge at New York; the former under the direction of Captain Eades as chief engineer, the latter under the direction of Mr. Roebling, to whom the United States already owe so many important works.

Fig. 13 represents one of the piers of the St. Louis Bridge in the act of construction. It will be seen that in this instance wood is largely employed as the material for the chamber in which the compressed air is to be used. The size of the chamber of this pier was 83 ft. long by 63 ft. wide; the working or air chamber was 9 ft. deep. Borings had proved that there was no efficient foundation until a depth of 140 ft. below the level of the highest flood in the Mississippi was reached, and it therefore became necessary to provide a chamber that would enable the operations to be carried on down to this depth, and to such ultimate height as to keep out even the flood water, should a flood come. Here, as in the Saltash and in the Kehl Bridges, the compressed air was used in the lower part of the vessel only, a diaphragm being made across at about 9 ft. above the bottom of the cutting edge, which diaphragm formed the roof of the air-tight chamber and the support for the masonry above. From the diaphragm extended upwards a central shaft containing a staircase, and having air-locks at its lower end, and not at the top, as hitherto had been the custom. This central shaft was for the workmen. The air-lock was put at the bottom to enable the workmen to make the ascent of the stairs, after their shift of labour, under the ordinary pressure of the atmosphere instead of in the compressed air. Other shafts were provided with air locks at the bottom for the admission of materials.

The caisson having been built and launched, was towed out to its place and secured there. This was done in one day; and

then, within a week, the masonry work of the pier was commenced above the diaphragm.

This was carried on until the weight of the masonry was sufficient not only to sink the caisson so that the lower edge came upon the bed of the river, but to force that edge some distance into the soil with a pressure due to that which was necessary to enable the upward force of the compressed air afterwards to be applied to be resisted. When this stage was reached air was forced in, and the workmen went into the chamber and commenced their labours of excavating. The material being nearly wholly sand, was got rid of by a very simple but ingenious apparatus—namely, the sand pump. This is an implement that works very much upon the principle of the Giffard injector, now so extensively used for forcing feed water into the boilers of locomotive and other steam engines. Water or air (in the case of St. Louis, water) under pressure is driven into the lateral orifice and issues into the central pipe by an annular opening. A suction pipe being connected to the pump, its lower end is inserted into a cavity containing the sand with some water; the induced current caused by the upward flow of the jet of water raises the sand and water past the annular opening, and then drives it upwards with such velocity as to carry it to the surface of the river, where it may be delivered either into the river itself or into barges. One of these pumps raised 20 cubic yards of sand 120 ft. high in an hour, with a water pressure of 150 lbs. on the square inch. The great advantage of such an apparatus will be readily appreciated when one remembers that it is free from all moving parts, and that if by any chance any material gets within it beyond the power of the jet to raise, all that happens is that on the jet being stopped that material falls to the bottom and can be cleared away at once, whereas with machines involving the use of valves and similar parts, if the action be suspended from the excessive weight or size of that which it is endeavoured to pass through, the whole machine becomes choked, and requires to be taken to pieces.

Before the completion of the work the air pressure had reached to as much as 52 lbs. to the square inch above atmosphere, being 2 lbs. or 3 lbs. in excess of the pressure due to the head of water on the outside. This excess arose from the power required to drive the air downwards through the sand, and out round about the edges of the chamber. It was ascertained that owing to the existence of this extra pressure the sand, which formed for the time the floor of the working chamber, was entirely devoid of water for a depth of from 8 in. to 10 in. below the cutting edge.

The effects of this pressure upon the workmen varied considerably. It showed itself much more strongly in some cases than in others. The first symptom felt was that which is well known to attend descending in a diving-bell, even to a short distance, namely, a pain in the ears, but a little practice in going through the air-locks caused this in most cases to be much mitigated, and even overcome; it merely requires that the effort of swallowing should be made two or three times rapidly, to relieve the pressure upon the ear. The pain is further relieved by closing the nostrils, shutting the mouth tightly, and puffing out the cheeks; and if this method be pursued from time to time as the air is let into the air-lock, much of the inconvenience is avoided. But if the Eustachian tubes are not in a healthy condition—for instance, if they are inflamed by a cold in the head—then the methods above described will not relieve the pain, and there is danger of rupture of the tympanum. In those cases, when it was found that the pain could not be mastered by the modes above indicated, the workman in charge of the air-lock was directed not to let the person suffering pass through, but to take off the pressure and to send him away. When the men were once within the chamber there was ordinarily no prejudicial effect, but with some workmen, after a pressure of about 28 lbs. on the square inch was reached, muscular paralysis of the lower limbs took place; in some cases the arms were subjected to this influence, and then the man suffered pain at the joints. But on an average not above one-tenth of those employed were affected with pain, and the others who felt the paralysis speedily recovered and returned to their duties. At first the length of a working watch or shift was four hours, but as the depth increased this time was reduced to three, then to two, and finally to one hour. The men believed very much in the efficacy of galvanic bands, and Captain Eades himself seems to think they were of benefit; but of the total number of 352 men employed, about thirty were seriously affected, and twelve cases proved fatal.

Each one of these cases was the subject of an inquest, and of careful medical inquiry. In half the instances, it was discovered that death was not to be attributed to the air pressure, while in the other half the deaths occurred to men who were unaccustomed to the work, several of them only having been in the chamber for a period of two hours in all. A large number of the men who were engaged in the works from first to last did not suffer at all. Observations were made to ascertain whether the ill effects were due to the act of the variation of the pressure, or whether they were caused by continued exposure to the dense air; and it would seem that the effect of rapid variation was not at all prejudicial. This was proved by the condition of health of the men who had charge of the air-lock, and these, although subjected many times in an hour to the alternate conditions of atmospheric pressure and of 30 to 50 lbs. above atmospheric pressure, did not suffer in the least. The conclusion come to was, that not the alteration of pressure, but the continuance in the heavy pressure, did the mischief. Many persons, including ladies, visited the working chamber, even when it was down to its full depth, and none of these suffered; nor in truth was there any suffering among the workmen after the duration of work was diminished to one-hour shifts.

It has long been known that compressed air intensified the rate of combustion, and there were several striking instances of this in the case of the St. Louis Bridge. Candles under a pressure of about 45 lbs. on the square inch above atmosphere were consumed in about three-fifths of the time that they would have required under ordinary circumstances, and large quantities of smoke were emitted. The air was filled with particles of carbon, and a jet of water from a fine rose had to be distributed throughout the chamber to cleanse the air from the smoke. It was endeavoured to cure this by burning the candles under funnels having pipes led to the shafts, and allowing a small quantity of the compressed air to escape. Oil lamps were tried, but were given up on account of the great danger attendant upon their use. The danger arises in this way. Under a pressure such as has been mentioned, and even in a less pressure, namely, that of about 32 or 33 lbs. on the inch, there is the greatest difficulty in extinguishing a flame when once started; in fact, one or two of the men who had fired their clothing by coming in contact with a light, were seriously burnt on account of this difficulty; and this was so although the men's garments were made almost entirely of wool. It was thought that if by any chance the men's clothing were to become greasy from the breaking of a lamp, or from any other cause, it would be impossible in the event of the clothes catching fire to extinguish them, and for this reason the use of oil was forbidden. Under a pressure of about 35 lbs. to the square inch, it was found that when a candle was blown out the flame would immediately reappear upon the wick, and with a pressure of 50 lbs. upon the square inch the flame returned after twelve successive blowings out, but the thirteenth was effectual. The lighting difficulty was at last cured by putting the candles into glass globes of sufficient strength to resist the pressure of the air.

As soon as the rock was reached, and the whole of the sand lying upon it was got rid of, concrete was gradually introduced to fill up that which had been the working chamber; the space between the stonework and the level of the river had been gradually filled in with the sand pumped out as the work went on, and when it was complete, the water was suffered to come into that which had been the coffer-dam, and the portion of it above the river bed was then removed.

In the manner I have endeavoured to describe was built in the middle of the Mississippi, with a current ranging from 3 to 4 miles an hour, and frequently encumbered with large blocks of floating ice, a most firm and substantial pier, to carry one of the boldest engineering works that has probably ever been attempted. This pier was completed in about six months from the time that the caisson was brought to its position. The period of actual execution was longer than this, because there was a delay of some weeks, arising from the stones not having been provided to execute the masonry work as rapidly as the caissons descended.

This bridge is an arched structure in steel; the arches are three in number, carried on two piers and two abutments. The river has a depth of water at this point varying from 17 to 58 ft. The river below has a sand bed, the same being in some parts as much as 80 ft. thick above the rocky bottom. Frequently, as in the case of Indian rivers, although not nearly in so great a degree, the bottom of the channel is scoured and lowered in places. It was upon a review of all these circumstances, that Captain Eades, the engineer of the Illinois and St. Louis Bridge Company, determined that any group of cylinders would be insufficient, more especially having regard to the pressure brought upon any such structures by the masses of ice, and he thereupon determined that the piers and abutments must be in solid masonry. The question then arose how, in such a soil, stone piers could be most quickly and economically constructed, and after much consideration he came to the conclusion that the compressed air process might be usefully employed.

The builders of the Kehl Bridge, as I have told you, feared to make a vessel large enough to embrace one of their piers, and they therefore used three vessels side by side; but Captain Eades

XUM

had no such apprehension, and designed his caissons of such size as to include within them the whole massive pier.

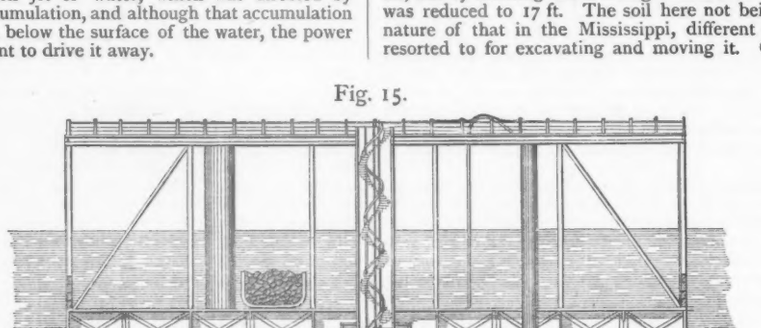
I have previously incidentally mentioned that hydraulic digging was used in the construction of the St. Louis Bridge. In getting down the west abutment—which from the comparative nearness of the rock to the surface it was hoped would be done with but little difficulty—the engineers were met by an artificial obstruction of the most serious character.

In the year 1849, twenty-nine steamers were burnt as they lay at the river bank, and two of them sunk upon the very site of this west abutment, one steamer lying upon the other.

The wrecked hulls had worked down through the sand, until they got within two or three feet of the rock. After these were sunk, the wharf was widened at that part by filling in rubbish and stones, which were deposited over the spot where the steamers were lying. Several steamers were afterwards burnt at this wharf, and the wreck of one of these came down to add to the curious stratification already existing, and it was through the oak timber of these wrecks that the piling of the coffer-dam had to be driven. When the dam was pumped out, it was found that all the wrecks had not been pierced—that the sheet piling had not got down to the proper position, and thus water came in and flooded the interior of the dam. Nothing remained but to remove the wrecks; but before this could be done, 15 ft. thick of stones and rubbish and other deposit had to be displaced. Recourse was had to an 8-inch jet of water, which was directed by divers against the accumulation, and although that accumulation was at that time 15 ft. below the surface of the water, the power of the jet was sufficient to drive it away.

The other great American bridge work to which I have alluded is the East River Suspension Bridge, between Brooklyn and New York. To support the chains there are two piers, the Brooklyn Pier and the New York Pier. The principle upon which the foundation for these piers was constructed was that which I have just described to you as having been used for the piers at the St. Louis Bridge. The circumstances were somewhat varied, for while the depth of water at the New York Bridge was less than that at St. Louis, the size of the caisson was considerably greater. For the New York Pier a satisfactory foundation was found at 78 ft. below mean high-water mark. The Brooklyn Pier found a foundation at about the same depth, and thus the caissons were not of that great height which I have mentioned as required in the instance of the St. Louis Bridge, but their plan dimensions were considerably larger. That for the New York Pier contained an area of 17,544 sq. ft., or $4\frac{3}{8}$ times as much as the east pier of the St. Louis Bridge, the area of that having only been 4,020 ft. At the New York Bridge a protecting ring of sheet piling was prepared to form a sort of dock, within which the caisson was to be held, so as to screen it from the current. The caisson having been launched was towed to within this enclosure, one side of which had been left open. A good deal of concrete was in the caisson at the time, and its weight as it was so towed to its place was 7,000 tons. It drew 23 ft. of water when empty of air, but by inflating the working chamber with air the draught was reduced to 17 ft. The soil here not being of the uniform nature of that in the Mississippi, different modes had to be resorted to for excavating and moving it. One mode was the

Fig. 15.



HUMBER TUNNEL.

employment of dredgers, which maintained a hole about 6 ft. deep under the sealed water-shafts, and removed from 300 to 400 cubic yards a day. Water under pressure was supplied also to the interior of the working chamber, and advantage was taken of it to act, as I have said, by hydraulic digging, for the purpose of loosening boulders and other embedded materials. In addition to the dredgers, there were as many as fifty sand-pumps, varying from $3\frac{1}{2}$ in. to 4 in. diameter, but in this instance some of the sand-pumps were worked, not with water, as at the St. Louis Bridge, but with a jet of air. This was found to be very satisfactory, 30 cubic yards an hour of sand being got through a $3\frac{1}{4}$-inch pipe from a depth of 60 ft. This quantity required the hard work of fourteen men, constantly shovelling the sand, and the necessary escape of vitiated air was sufficient to supply three such pumps, or to keep sixty men fully employed.

Implements like these are all clearly of great value in the carrying out of such works, and some notion may be formed of their power, when I tell you that stones and gravel were occasionally sent as high as 400 ft. above the top of the caisson. This, of course, could not be allowed to continue, and in fact, if the feeding were well attended to, no such projection as this took place; but, nevertheless, as the feeding might run short, and then the stones came up with a fearful velocity, it was necessary to deflect the discharge at the top of the pump, and to deliver it horizontally. Elbows or bends, as well of wrought as of cast iron, were tried for this purpose, but the sand cut them through in an hour or two, and sometimes even in a few minutes, although the iron was $1\frac{1}{2}$ in. thick. Recourse was then had to using a cap of chilled iron, and this would generally last two days; finally, the attempt to employ elbows was given up, and a heavy granite block was placed at some distance above the end of the pipe, and against this block the materials impinged, and were deflected downwards into the external coffer-dam. But, in spite of the precautions, some accidents happened. One labourer had his finger injured, and another was shot right through the arm.

As I have said, boulders were met with in sinking the caissons, and some of these had to be got rid of by blasting, a matter requiring great care, when it is recollected that any excess might have ended in blowing up the air-chamber itself.

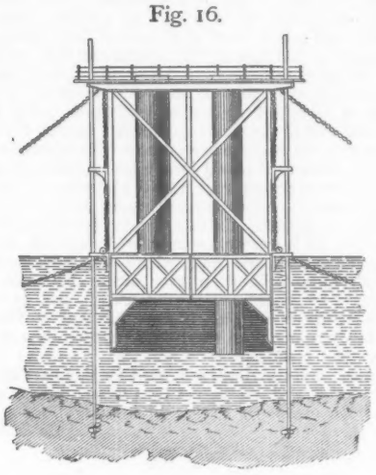
The lighting, in the case of this bridge, was done by ordinary coal gas, which was burnt at a pressure of 1 or 2 lbs. in excess of that of the air in the caisson for the time being. Proper means were taken to preserve the relation of pressure. One interesting fact was observed, and that was that all the gas-lights when burnt in compressed air responded to every blow of a hammer, and even to the tones of the voice.

Hitherto I have occupied the attention of my readers exclusively with the consideration of bridge foundations, but I need not say that there are other subaqueous engineering works, such as tunnels, and in fact it might well be said, that any paper that professed to give even the most cursory view of subaqueous engineering would be obviously incomplete if all mention of that executed work, the Thames Tunnel, which has now for so many years existed between Rotherhithe and Wapping, were omitted, and if such projected work as the tunnel under the Channel and the tunnel under the Humber were passed over in silence; but the remaining space at my command is so short that I fear I must dismiss with the bare mention of their names both the Thames Tunnel and the Channel Tunnel, and I shall do so with the less reluctance, because I believe the construction of the first is known to almost every one who takes the slightest interest in such matters, and the condition of the second is as yet too unsettled to enable me to give you anything

like a useful account of it. I will therefore devote the space that remains to a consideration of the tunnel that was projected by Mr. Fowler, last year, to carry the Hull and South and West Junction Railway from Hull to the other side of the river Humber.

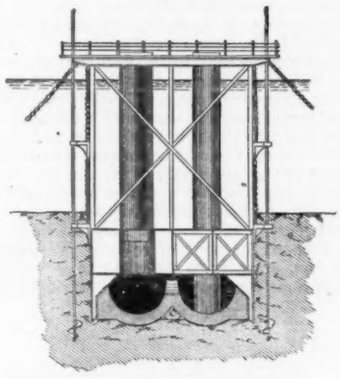
It will be observed that in all the prior works I have noticed,

Fig. 16.



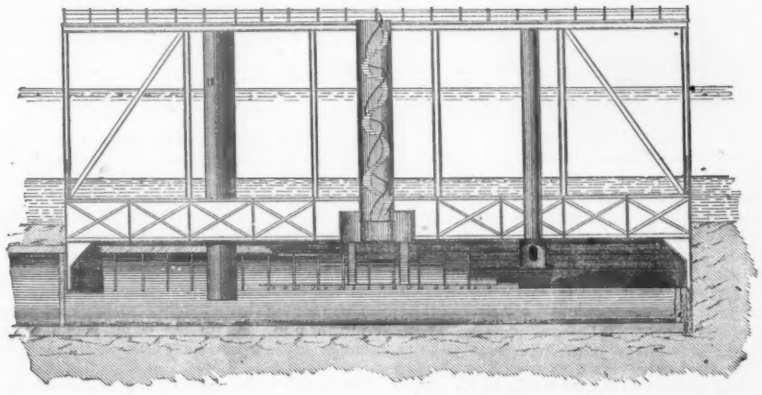
the various ingenious and able devices resorted to were employed for the purpose of erecting isolated piers or abutments, and not for the making of any continuous structure, and it will also be seen that, except in those cases where the diving-bell is used, the caisson or other apparatus, if it do not constitute the structure itself, as in the cylinder foundations of the Rochester Bridge and other bridges, remains as a portion of the structure, as in the case of the piers of the Kehl Bridge, the St. Louis Bridge, and the East River Bridge, and thus there have to be provided as many expensive caissons as there are portions of work to be executed. The ordinary mode of constructing a tunnel, as is well known, is to go a sufficient depth below the bed of the river into a safe soil, and then to excavate the tunnel as it would be excavated through a hill; but in the case of

Fig. 18.



the projected tunnel under the Humber this course was not possible. Borings showed that no reliable soil could be found except at such a depth below the river as would have been prohibitory, on account of the steep inclines that must have been made on each side to afford access to the tunnel. The remedy

Fig. 17.



for this, I may say, was obvious, namely, to endeavour to construct the tunnel from above;—to do, in truth, that which is known in railway works on land, where a covered way is carried under a slight depth of soil, as "cut and cover." But in the instance of the Humber tunnel, the "cut" had to be made not only through the land but through the water.

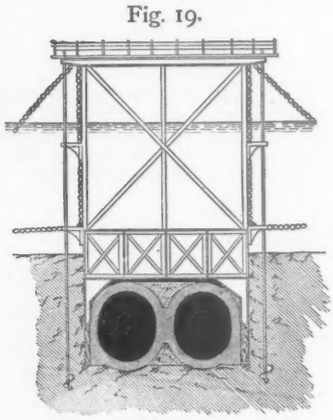
Mr. Fowler, knowing thoroughly well all that had been done with the use of compressed air, determined to carry out the tunnel by that process, but so to carry it out that the caissons employed should not be built in as a part of the work, but should be capable of being used over and over again for successive portions; and also so to carry it out, that although the tunnel would be made in separate lengths within the caisson, these lengths might be jointed the one to the other. I will now ask your attention to figures Nos. 15, 16, 17, 18, and 19, which show the method by which it was intended to execute this great work.

Three caissons, each 160 ft. long by 42 ft. wide, were to be provided. Each was to consist of a flotation and ballast chamber of the size I have mentioned, by 12 ft. deep, from which would hang the sides of a diving-bell, or working chamber, of the same size as the flotation chamber, and also 12 ft. deep. On the top of the flotation chamber was to be erected an iron scaffold or framework, strongly and securely braced, carrying the upper deck, on which would be placed the engine-house and all the requisite machinery. Ballast barges of a suitable size were also to be provided, which at the proper time, as I will explain, could be placed on the top of the flotation chamber, or could be removed therefrom. Carried in brackets on the side of the framework, were to be a number of screw piles, capable of being raised or lowered by chains, and of being turned by steam power. There were also to be steam winches, to which the mooring chains were to be attached. The mode of operation was as follows. One of these caissons was to be towed to a spot over the site of the tunnel, and then the mooring chains were to be made fast to buoys already placed in position; these chains were to be hauled on by the steam capstans, until the caisson was got over the intended spot. Water was then to be suffered to come into the ballast chamber, and the caisson was to be gradually sunk. The nature of the bottom would of course have been previously ascertained by soundings. If the bottom were practically level, the caisson would be suffered to go down and take its bearing upon it, and the lower edge of the working

chamber would cut itself into the bed of the river. Then more water was to be admitted into the flotation chamber, and air was to be introduced into the part I have called the working chamber, so as to expel the water from that chamber; men were then to enter the chamber by the shafts and air-locks, and were to commence to excavate, removing the material, according to its nature, either up a water seal shaft by dredgers, or up sand pumps by air or water jets. The ballast barges I have spoken of were then to be towed on to the top of the flotation chamber, and were to be allowed to settle there as the tide went down. Water was then to be admitted into them, so that on the next rising of the tide they would not float, but would remain as a definite load on the top of the flotation chamber. The downward force of the whole structure, with the ballast barges and the permanent ballast in the flotation chamber, would be 2,500 tons. In this way the excavation would go on until the bottom of the caisson was down to the level intended for the bottom of the tunnel. The ground having been got out, and levelled to truth, would be covered with a layer of concrete, upon which the brickwork would be commenced, and this would be carried up as high as the top of the chamber, and thus would be formed the two inverts and the side walls up to the half-height of the tunnel. By this time the top of the working chamber would be nearly reached.

If the screw piles had not previously been inserted into the bed of the river they would now be screwed down, and then would be commenced the work of re-using the caisson. This, as a matter of fact, in order to make the joint with the neighbouring and previously executed piece of work, would be done

Fig. 19.

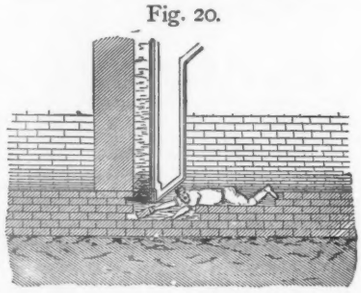


step by step by intervals of about 6 in. But I will, in the first instance, for simplicity's sake, suppose that the caisson would be taken up at once the whole height of 12 ft. Preparatory to raising, I should have said the ballast barges would be removed from the top, and air being introduced into the flotation chamber, the water would be expelled from it, and in this state of things there would be an upward tendency which could be regulated from nothing up to as much as 2,500 tons. By means of the attachment to the shanks of the screw piles the caisson could be controlled with the greatest nicety. As soon as it had reached to a height of 12 ft., space would be afforded for the upper part of the tunnel to be completed, and this would now be done within the caisson, upon centreings provided for the purpose; then the caisson would be further raised, step by step, for the purpose of making the junction of the brickwork, and this being done, it would be removed, and the bed of the river would be made good over the top of the tunnel. Then this caisson, or another caisson, would be re-sunk at the end of the work thus executed, and within a few inches of it, and another 160 ft. of work would be gone on with. It will be seen that by this arrangement the caissons were not lost each time they were used, but were recovered, carried from place to place, and made useful as often as was required until the whole work was completed.

I will now go to the question of the jointing of one length of work to another. Each length, as it was finished in the caisson, would have a toothing, as it is called, left at the ends of its walls, and a temporary cross wall would be built close to the end of the section of work; holes being provided in this wall to allow for the flow of the water. Against this cross wall and the toothing would be fitted in a sort of weak concrete, sufficiently strong to stand against the work, but sufficiently weak to admit of the cutting edge of the caisson on its re-descent shearing through it. Imagine a piece of work to be thus finished, with the toothings and weak concrete provided; the next caisson would be brought, as I have said, within a few inches of the toothing that was left, and would then be sunk, cutting down through the weak concrete. The object of this concrete is to prevent any running of sand which might have occurred if no such provision had been made. Imagine now that the lower half of a second portion of work has been built within the caisson, and that the object is to unite it to the section previously formed. The caisson, as I have said, would be raised 6 in., the position being exactly controlled by the screw piles; the result of this raising would be that the water would flow in, and would rise 6 in., that is, level with the bottom of the caisson; the workmen then would go to the end next the formerly executed portion of the tunnel, and would first of all unroll a piece of lead flashing that had been built in to the end of the previously formed section of the tunnel, and had been curled up there in readiness. When this piece of lead flashing was unrolled it would form a lead bottom to the space between the last executed work and the interior of the caisson, and resting upon the excavated soil would prevent any blowing up or boiling of that soil. In this way the bricklayer would find himself within as it were a room (the diving-bell or working chamber), having at one end, where the brickwork was to be executed, water 6 in. deep over the leaden floor. In this 6 in. of water he would lay the brickwork, and he would lay it the few inches, 6 or 9 in., beyond the end of the caisson, that is to say, far enough to reach into the toothings of the previously executed work.

The cement would be Portland, used for this part of the work without any sand, and put on, not by a trowel or in the ordinary manner, but by means of a pipe proceeding from a vessel at

Fig. 20.



HUMBER TUNNEL—JOINT MAKING.

some little height and containing the mixed cement. In this way the neat cement, as it is called, would find its way between the joints of the bricks. I suppose I need hardly say that executing brickwork with neat cement under water by the aid of the diver, or in any slight depth of quiescent water, is an ordinary and recognized mode of carrying out work, and that the result is entirely satisfactory. In this manner, as I have said, 6 in. of brickwork would be laid in the water, coming up just to the level of the water, that is, fair with the bottom edge of the working chamber of the caisson. The caisson would then be raised a further 6 in. Again the water would reappear 6 in. deep over the brickwork previously laid. In this water another 6 in. of brickwork would be bedded, and so 6 in. by 6 in. the caisson would be raised until the jointing brickwork was completed. The sides of the tunnel and the roof, it will be seen, were to be covered with puddle. When all the sections of the tunnel were finished pumps would be put to work at the ends, and the water would be withdrawn, running through the holes left in the cross walls for its passage. Nothing would then remain but to enter the tunnel, clear out the cross walls and dirt, and lay the permanent way.

I have not the shadow of a doubt but that this most thoroughly-thought out plan of Mr. Fowler's invention would have successfully accomplished the tunnel under the Humber; and I regret extremely on every ground, especially on engineering grounds, that the work is not now in progress, as I feel that such a work would have been the crowning triumph of pneumatic subaqueous engineering. Hitherto, as I have said, isolated works alone have been accomplished, but the Hull tunnel would have shown how this most ingenious mode of executing work by aid of compressed air could be employed not for mere detached foundations but for continuous work such as the Humber tunnel.

THE PLOUGH—ITS HISTORY, CONSTRUCTION, AND MANAGEMENT.

IN our article at p. 442, vol. i. of this Journal, we carried up the consideration of our subject to the action which was exercised upon the form of the furrow slice, not only by the mould-board, but by the coulter and the share, the two latter members of the plough influencing this in a way very marked and decided, but frequently overlooked by some. These influences of the share and coulter, although however by some not overlooked, are nevertheless thought to be more as incidental influences than as brought about by what may be called the essential part of the plough designed to exercise this influence upon the form of the furrow slice, this being looked upon as the peculiar duty of the mould-board alone. And to this part or feature of the plough no doubt the greatest share of attention has been given, and when we go more fully into its consideration, we shall come perhaps to the same conclusion that all others have done who have studied the plough as a whole, that it has been rightly and justly so given. It is to this part, therefore, of the plough—the mould-board—that inventors have chiefly directed their attention, and it will be not only suggestive, but of great practical interest, if we go somewhat into detail as to the investigations which have been made into what would constitute the best outline to give to the mould-board, so that it would yield the highest percentage of efficiency in the soil upon which

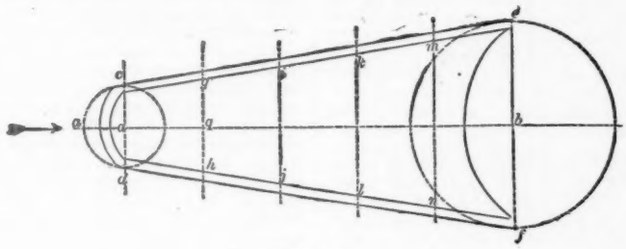


Fig. 37.

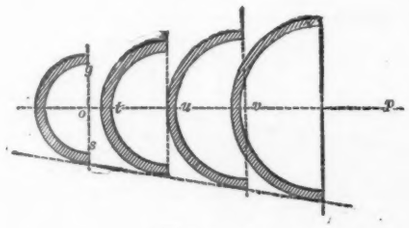


Fig. 37 *a*.

it operated. And here it will serve to clear the ground before us, if we place before our readers unacquainted with the details of the subject, what may be called its elementary points.

If we suppose the mould-board to be simply the half of a conical wedge, as represented in fig. 37, its construction could at all times be secured with a fair approach to something like rigid accuracy by taking the length *a b*, and dividing its lines into any number of equal parts, and through these drawing ordinates or lines at right angles to *a b*, which in this case goes through the

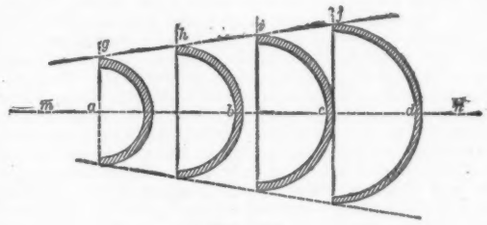


Fig. 38.

centre of the cone. Sections of cones at any point at right angles to a line drawn through its centre, are circles, and of a half cone, semicircles, and if that be hollow, hollow parts, the thickness of the shell, so to call it, varying according to circumstances. Thus in fig. 37, if *a b* be the central line of a half conical and hollow body, *c d e f*, and ordinates, as *g h*, *i j*, *k l*, *m n* be drawn at equal distances on the line *a b*, and these be produced to cut a line *o p*, fig. 37 *a*, then if from the point *o* with radius *q g* or *q h*, a semicircle *r s* be described, this will give the section of the part at *q*; in like manner the sections on the lines *m n*, *k l*, *i j*, will be produced at the points *t u v*. Should now a semi-conical hollow body present its hollow part to the soil in place of the convex side, as in fig. 38, then the sections will be at *a b c d*, and the ordinates *g h i j* taken through the central line, *m n*. But these sections might not be semicircular, but arcs of circles of less radius than half of the length of any one of the ordinates. Thus, as in fig. 39, the section *a*, corresponding to *a* in fig. 38, may be half a circle, but *b* might be

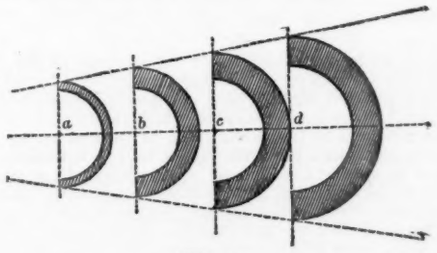


Fig. 39.

less than this by one-third of the diameter, *c* one-third, and so on, giving a different internal contour to the semi-conical body,

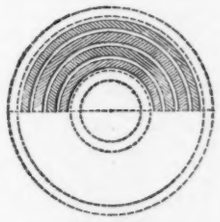


Fig. 40.

as in fig. 38. Looking transversely to the body, as in fig. 37, as in the direction of the arrow, we can conceive of it assuming the sectional forms as in fig. 40, the sectional lines representing

the larger and smaller ends of the cones, the full but narrow lines, the lines of the sections, as *o t u v* in fig. 37. But in place of the body being conical, as in fig. 37, rising gradually from a small to a larger part, as *a* and *b*, with a surface or contour in a straight line, as represented by the line *f d* in fig. 37, we may conceive of it presenting a contour irregular as in fig. 41, where the part towards the right hand, as between *a b a* and *c d* is convex, the part between *c d* and *g h* nearly flat, while the part

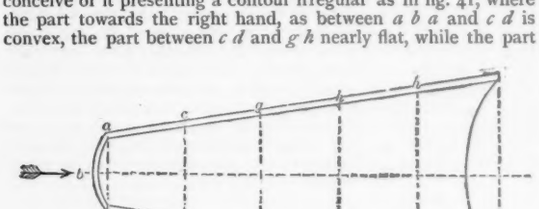


Fig. 41.

between *g h* and *h i* is concave, the remaining portion being convex. The vertical sections—that is, looking in the direction of the arrow *q*, and at right angles to the line *b*, would vary in outline or contour. Thus in fig. 42 another illustration of the principle may be given, in which the conical wedge *a b c d* may be said to embrace within its limits the curved mould-board *e f*; the part *e* being concave, gradually tapering off to a flat portion, *g*, convex at *h*, and gradually, sloping from *h*, to a flat surface between *h* and *f*; and if this were cut by vertical ordinates, at determinate lengths, these would give sectional lines, the sum of which would make up the outline of the mould-board. These are merely hypothetical cases, but they will serve to make more plain to the reader the method by which the contours of various mould-boards of ploughs are delineated or projected, and will be introductory to the consideration of the closer applications of principles which have been put forward by various inventors and improvers of the plough. It is the opinion of some that there is a "real law of nature which ought to regulate the shape" of the mould-board of a plough useful in all soils. But it is that of others that this shape should not be unvarying, but that this depends, or will depend, upon the character of the soil in which the plough is made to work; that one plough will thus give good work in one soil, and bad or indifferent work in another. Further, it is obvious why those who hold this opinion that the contour or form of the mould-board of the plough will really, or ought to, depend upon the character or kind of the work which it is designed to do, that the first thing to determine is what is the character of that work. It may appear a somewhat strange thing for our readers to be told, after all we have said, that that character of work is one of the vexed questions of practical agriculture so far as ploughing is concerned, and we shall see, as we proceed, that there are two schools, each of which hold views as to what the plough should do in the preparation of the soil for the reception of crops, very diverse indeed, and necessarily influencing the principles upon which the plough is designed. It will be well, therefore, here at this stage of our inquiry to glance at some of the points bearing upon the whole question.

More than twenty years ago—nearer, in fact, the thirty than the twenty—the then greatest living authority on agricultural matters penned the following sentence, which conveyed the terms of what may be called the standard of perfection in

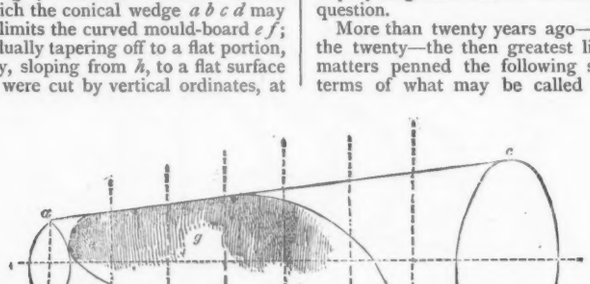


Fig. 42.

ploughing, as then received: That the operation of the plough should be such "that the furrow slice shall lie, after being turned over, in a perfectly straight line, not only unbroken, but even uncracked." This was the standard which judges at our ploughing matches, and at the public trials of ploughs at our great agricultural meetings generally had in view in determining the merits of competing implements. There might be at the time we have above alluded to, and for several years afterwards, agricultural authorities who took the standard with certain reservations; but as a rule it was that which was held by nearly all authorities. This, it may be conceived, influenced to a very remarkable extent the endeavours of implement makers to meet a form of plough which should give the characteristic features of this standard to the work which their ploughs were meant to perform; and the result was that, with few exceptions, the ploughs of English makers presented those features so familiar to those who have had an intimate acquaintance with the agricultural machinery of the last twenty or twenty-five years. Long mould-boards with easy-going lines, in which the absence of abrupt, short convex curves, and the presence of long and generally concave curves, with a uniform twist, were the conspicuous features were met with universally. At the period when the standard, as we call it, was penned in the words we have quoted, ploughing, as an art, was a very complicated affair, and involved the exercise of no small amount of manual skill, not merely in the actual working of the plough, but in the laying down of the field under certain fixed rules or principles, according to the style in which it was to be finished. These complicated processes may still be read of in works published a decade or two ago, and their authors little dreamed—nor did the writer of the "standard" we have quoted likely dream—that the time would come, and soon, when all these complicated processes of laying down and finishing off fields for ploughing, would be to a large extent superseded by a system of working so rough and so opposed in all its features to the prim precision of the work of the plough as given in the words we have quoted, that it is now known by the term, as we think peculiarly appropriate, of "smashing up;" this rough work—for rough it is, judged by the precise standard of ploughing—being now often performed by implements which possess few or none of the features of the plough at all. And yet this work is so thoroughly good of its kind that farmers are not seldom met with now, famous for the crops which their lands produce, the soil of which has not been touched for years with the plough; which, as we have seen, turns over its furrow slices with unvarying precision of form, evenness of surface, and solidity of substance. A few sentences will show how this has come about. Popular notions, although often singularly enough derived, frequently hit in a rough and ready way the truth of a matter; and it is so in regard to the condition in which a soil apparently requires to be. If the question were asked in a general way from the generality of people as to what that condition should be, the answer would in nine cases out of ten assuredly be, "that namely, which is met with in a well-worked garden, where the soil has long been under the spade, and a long-continued succession of crops has been taken from it." An examination of this soil would show at a very cursory glance that its principal characteristic was its thoroughly broken-up and pulverized condition. And if the process of working it was observed, it would be noticed that the very mode of working it, namely, by the spade, necessitated its breaking up and pulverizing. Spade culture then would appear to present the best method of bringing a soil into good condition; and that being the implement wholly, if not chiefly, used in gardens, the conclusion would be come to that the nearer we could make the soil of our farm fields approach to the condition of that of our garden plots, the better would our farm

crops be; and that the best implement for the purpose would be the spade. But while it is universally admitted that garden soil presents the features which farm soil should present—so universally admitted that when it is desired to give the highest praise to a farm soil, it is stated to be "as fine as a garden,"—nevertheless, it is unfortunately the fact that the implement which gives such fine results in the garden, namely, the spade, cannot be made economically useful on the farm. It is unnecessary to go into a statement of the reasons why "spade" culture is a practical impossibility on our large, or even moderately large farms; we simply content ourselves by pointing out the fact that it is so. But seeing the undisputably valuable work which it gives, the question has been often asked in the past—is still being asked, Can we get no implement which, while it can be as economically used on the large as the spade is used on the small scale, will give all the advantages of the spade? The plough in many respects does, in some it does not; and there are ploughs and ploughs—ploughs which give good work, ploughs which give bad work, when judged by the standard of garden or spade culture, namely, that which gives a broken-up, pulverized condition, to the soil in which they work. We shall see as we proceed what influence the mould-board of the plough has upon this condition of soil; meanwhile it is necessary to point out in as brief a fashion as may be the beneficial effects of working the soil and bringing it into the condition which good deep spade culture does bring it into, deducing therefrom some considerations bearing upon the form of the plough mould-board. This is not the place to enter into all the agricultural features connected with the question; we can do little more than point out generally some of the leading points. All plants derive their constituents from two sources: first, what may be called "atmospheric;" second, the "inorganic." The atmospheric comprises two classes of fertilizing agents, the air and water. The influence of the atmospheric agencies are very marked, although for long they were much overlooked, and are, indeed, still overlooked by many. Land which is exhausted or worn out, if allowed to remain for a length of time exposed solely and only to these atmospheric influences, will become again fertile; and if subjected to culture will again raise fine crops. To admit of the action of these influences it is obvious that the soil must be in a certain condition; and it may be in a bad, it may be in a good condition. If it is hard on the surface, if the particles are closely compacted together, it is beyond a doubt that the air and rain cannot possibly penetrate the soil in such a complete way as if the surface were open, the particles loose and friable. The other source of plant fertility we have named are the "inorganic" constituents which are either present in the soil or added to it in the form of manures of various kinds. The inorganic constituents in the soil are very unequally distributed; one part of a field may indeed be almost destitute of certain constituents valuable for a certain crop, while another part may have more than the crop requires. This inequality in the mineral or inorganic constituents of a soil gives rise to many puzzling circumstances in practice, from its being overlooked or unknown, and also to a diversity of results in agricultural experiments. The same remark may be made of the inorganic constituents supplied to soil in the shape of manure; these may be very unequally distributed; one part of the soil receiving the maximum, another the minimum supply, while a third may, in fact, receive none at all. These facts point to the benefit of a thorough mixing of the soil so as to render it of as even or uniform a quality as possible. Further, although the inorganic constituents in the soil may be abundant as regards quantity, and all that is required as regards specific quality, still they may be in such a condition or state relatively to one another, and to the plants which are to draw upon them for nutriment; that they may not be available by the plants, and still further, the soils may not be in a condition to absorb or take up these inorganic fertilizing constituents. Without going into the minutiæ of the matter, suffice it to say that soils, when finely divided as regards mechanical conditions, are in a state better fitted to absorb the fertilizing matter of the inorganic constituents present in the soil, than when they are in a hard, close, and compact one. And, on the other hand, that the fertilizing substances thus absorbed by the soil, are given out—so to say—or are best separated or taken from it by the action of the rootlets of plants, these having a far higher power of assimilation than water, or indeed any known agency. From this is deduced the practical fact, that the greater the facilities we give to the rootlets of our plants for penetrating the soil, the greater is the supply of fertilizing matter we give to them, that being supposed to be present in the soil. Now it is also obvious beyond a doubt, that rootlets of plants will penetrate a soil, the particles of which are loose and friable, with much greater ease than when these particles are impacted to form a hard mass more or less solid. And, as if to aid in this direction, it is a curious and for us a fortunate thing that the powers of plant rootlets to extend themselves far into the soil in search of food is very great, and it is a singular point, worth noticing here, and one not altogether without its practical bearing on the subject, that this power is developed in a different way in different plants according to their necessities, some having a tendency to send their roots deep down in a vertical direction, others far away in a lateral direction. We have still further to point out that of the inorganic substances in soils, some require to be placed for a long time under the atmospheric influences before they can be put in a condition, so to say, in which they can be made valuable for the food of plants; but it is also noticeable that this change is much more rapidly brought about when the soil is in a good mechanical condition—that is, loose and friable—than when it is in the opposite condition. Now it so happens that the most active agent in thus quickly changing the condition of these inorganic constituents from an inert to an active condition is that which is brought most quickly and favourably into play when the soil is in this open condition. But this open condition brings into favourable operation causes which add greatly to the fertility of the soil, other than those already named—such as the influence of the atmospheric heat on the surface of the soil where it is beneficial, the evaporation of stagnant water, the deposition of refreshing dews, and the rapid and healthy germination of seeds. Having then shown very briefly the advantages derivable from an open, friable, well mixed and deeply stirred condition of the soil, we shall be able to trace, as we proceed, how far the plough is capable of giving us this condition, and whether the form which is considered to be the best, is that which is the best calculated to give this condition, or whether some modification in its form be not demanded by the requirements of the case as Nature herself puts it to us.

NOXIOUS TRADES AND PROCESSES: PRECAUTIONS IN ENGLAND.

IN a former article (p. 189, No. 21) we gave a brief outline of the measures adopted in France for lessening the evils attending the carrying on of manufacturing operations, when the processes are of such a kind as to be injurious to health, or offensive to the inhabitants of houses in the vicinity. We will now attend to the proceedings in England; and this we shall do with somewhat greater fulness of treatment, because it touches ourselves more nearly, and because the sources of information are more abundant. The English are more accustomed to be self-reliant than the French, to manage their own affairs in their own way, with as little interference as possible on the part of the Government or the Legislature. Nevertheless, some evils are so wide-spreading as to need the strong arm of power to subdue, especially in sanitary matters.

Remedial Measures Anterior to 1862.

The attention of the legislature has been drawn to this subject by slow degrees. An act was passed in 1820 for abating the nuisance of smoke from steam engines. It provided for the institution of actions at common law for damages, to be brought by those who had suffered injury or material inconvenience. There were, however, so many exceptions made, at the instance of those who had influence in parliament, to the kind of engines brought under the operation of the law, that the statute became almost a dead letter. Among the exceptions were two, which unfortunately produced smoke in great abundance, viz., the steam-engines employed in smelting works and chemical works. The Public Health Act in 1848 was the first that interfered in a direct way with establishments carrying on unhealthy trades. Two modes of proceeding were sanctioned: (1) Action at law for damages in individual cases of injury; and (2) Indictment for general public injury or nuisance. The first source of remedy proved unsatisfactory, because it was costly to one or both parties; because it was sometimes difficult to prove which of two or more manufacturing establishments had wrought the mischief; and because the nuisance was still continued after a verdict, even if for the prosecution, had been given. The method by indictment also failed to realise the intentions of the legislature; for the prosecutor had to show that the nuisance was continuous, not merely temporary and accidental; and he was also required to show that the injury affected the public generally, and not merely a few persons. Moreover it was difficult to obtain a conviction: and, if obtained, the fines were too small to

deter manufacturers from continuing a system to which they had long been accustomed, especially when preventive or remedial measures would have been expensive to adopt.

Numerous provisions are scattered through various Acts of Parliament, some applying to the metropolis only, some to the whole kingdom, and some to all places except the metropolis, relating to noxious trades. These statutes comprise the Towns Improvement Clauses Act, the Public Health Acts, the Local Government Act, the Nuisance Removal Act, the Smoke Prevention Acts, the Metropolitan Local Management Act, and others passed between 1848 and 1861. Of these the Nuisance Removal Act (1855) was the most general in its application. Under the provisions of this statute, the local authority may demand admission for an inspector into any establishment where nuisances are supposed to exist; especially those in which the operations are carried on connected with tallow-melting, candle-making, soap-making, slaughtering, blood-boiling, offal-boiling, bone-boiling, and bone-burning. Here again, however, the intentions of the legistature were far from being realized. The Act was so badly drawn that evasion was easy; the hours for inspection were too few, leaving an obstinate offender long portions of each day (or night) for doing that which would not bear the test of inquiry; the exercise of magisterial power was too dilatory; the list of trades was so drawn up as to leave many of the most offensive untouched; the offenders, if prone to battle with the law, could put the local authority to a heavy expense by an appeal to one of the superior courts; and by limiting the operation of the Act to cities, towns, and populous places, an opportunity was afforded to the offender of exercising his ingenuity in showing that his place did not come within the range of these appellations.

The Public Health Acts of 1848 and 1858 were placed at the option of the ratepayers, to decide whether they would adopt them or not in their particular town or district. Those who disliked this kind of legislation, as entailing trouble and expense upon themselves, were not slow in discovering that a doubt might be raised concerning the application of the statutes in the case of noxious gases. The Acts were weakened, too, by the exemption from their operation of the smoke nuisance in coke works, lime-kilns, ore-roasting, brick-burning, pottery works, mining furnaces, blast furnaces, wrought and cast-iron works, and glass works. The local authority, it is true, had some power of deciding whether these establishments should be excepted or not; but as the leading manufacturers were often members of the board, the decision was liable to be warped by motives of self-interest.

The Smoke Nuisance Abatement Acts of 1853 and 1856 applied only to the metropolis. They provided for the enforcement of penalties, if the case proceeded to conviction, against "Any person who shall carry on any trade or business which shall occasion any noxious or offensive effluvia, or be otherwise injurious, among the neighbourhood or inhabitants, without using the best practicable means for preventing or counteracting such annoyance." But weak points were soon discovered, and manufacturers succeeded in tearing sundry holes in these statutes.

The Metropolis Local Improvement Acts of 1856 and 1861 were found to be exposed to a difficulty already hinted at—the influence of wealthy manufacturers on the decisions of the local authorities, even without actual membership of the respective boards.

Committee and Statute on Alkali Fumes; 1862 & 1863.

A committee of the House of Lords, in 1862, recommended a consolidation of all the statutes relating to nuisances; a more extended scope to be given to the operation of smoke prevention clauses; an application of them to furnaces giving forth deleterious gases, as well as smoke; a power to be given to sanitary inspectors to enter any works where noxious manufactures are carried on, at all hours when the operations are actually in progress; and a system whereby cheaper and more summary proceedings could be adopted towards offenders. The committee expressed a belief, founded on voluminous testimony, that nearly all deleterious gases and vapours *can* be either consumed or condensed, either in the furnace itself or in some chamber or apparatus connected with it; and that if manufacturers were compelled by law to do this, they would find out the means. A difficulty that presented itself to the attention of the committee was this—that if a noxious trade is carried on near the boundary between two parishes or districts, interference is only allowed to the local authority within the parish or district where the works are actually situated; although the adjacent locality may suffer nearly as much from the fumes, or even more so if the prevailing wind at that place is in a certain direction.

The committee just adverted to, which prepared a really valuable report in 1862, made suggestions relating to various branches of this large subject, as above noticed; but the more immediate matter, which led to legislation soon afterwards, was comparatively limited in its scope. The duty intrusted to the committee was to inquire "into the injury resulting from noxious vapours evolved in certain manufacturing processes; and into the state of the law relating thereto." The inquiry was confined to vapours injurious to health and vegetation, and did not take cognizance of those which are merely offensive. Dr. Lyon Playfair drew the attention of the committee to certain chemical manufactures against which safeguards were essentially needed: one is soda, which gives out hydrochloric or muriatic acid gas; a second is sulphuric acid, attended by the evolution of nitrous gas; a third is a series of ammoniacal salts, leading to the throwing forth of sulphuretted hydrogen as a poison into the atmosphere; and a fourth is the smelting of copper and lead, by which is liberated sulphurous acid gas—a vapour peculiarly deleterious to vegetation.

Experience has shown that the soda manufacture is very hurtful to trees and plants, sometimes to a distance of six miles from the factory. Within one or two miles the trees lose their leaves, the top branches begin to decay, the bark becomes discoloured and hardened, and the tree virtually killed. St. Helen's in Lancashire, a great centre of this branch of industry, was described at the period of the committee's inquiries as "one scene of desolation. You may look round for a mile and not see a tree with any foliage whatever on it. Three-fourths of the trees are totally dead. Ten years ago a beautifully thick plantation of trees stood in front of a country residence; there has not been a leaf on those trees for these two years. Farms recently well wooded, and with hedges in good condition, have now neither tree nor hedge left alive; while fields of corn are destroyed in a single night, especially if the vapour falls upon these while in bloom; orchards and gardens, of which there were great numbers in the neighbourhood of St. Helen's, have not a fruit-tree left alive; pastures are so deteriorated that graziers refuse to place stock upon them." To add to the evil of the soda fumes, the coal consumed in the immediate vicinity of St. Helen's—600,000 to 800,000 tons annually—is very sulphureous, giving off 12,000 to 14,000 tons of sulphur, enough to make 36,000 to 40,000 tons of sulphuric acid.

The alkali makers had begun to adopt some measures for lessening the evil of which their neighbours so much and so justly complained. They built towers, filled them with coke, and allowed water to trickle down through them: the hydrochloric acid gas, given off in the soda manufacture, was admitted into the tower, where it was absorbed by the descending drops of water, and converted into liquid muriatic acid. Instead, therefore, of a deleterious vapour being sent off into the atmosphere, the manufacturer obtained a liquid acid useful in many chemical and technical processes. But there is not a demand in the market for so much as would be thus produced; and hence some difficulty was felt in getting rid of the remainder. Another source of embarrassment to the soda manufacturer was the accumulation of alkali waste—a sulphuret of calcium which gives off an offensive sulphur vapour, and poisons the streams when washed down by rain. Enormous heaps of this substance have grown up around the chemical works; for the manufacturers knew of no mode of applying it to use.

The ammonia alum manufacture gives forth noxious vapours almost as bad as that of soda. Copper smelting is doubly bad, for it produces both sulphur fumes and arsenic fumes. Lead works also give forth unhealthy exhalations, but not so deleterious as those from copper.

The Committee, in deciding on the recommendations to make to parliament, thought it prudent to limit the scope of legislation by applying it to those evils only to which there were *known* remedies available. This was certainly the case in regard to the alkali manufactures, but it was not so certain in the smelting of copper and lead. They thought it would be well to begin with a special Act of Parliament for alkali works only. Manufacturers should be compelled to condense, consume, or render innoxious the vapours produced during the successive operations, but should be left to their own choice of means. Provision should be made for the visits of inspectors to the works, and for the enforcement of penalties in the event of any contravention of the Act.

It fortunately happened that the principal manufacturers expressed their willingness to be brought under the operation of such a law; they recognised the object in view as a good one, and believed in the practicability of realizing it without any pecuniary loss to themselves; nay, they thought a well-matured plan likely to be profitable to themselves, as well as a great relief to their neighbours in the fields and woods, farms and gardens.

An Act of Parliament was passed in 1863, to give effect to the recommendations of the committee in regard to alkali works; being thus limited, it is known as the Alkali Act. The manu-

facturers are bound to condense into a liquid form ninety-five per cent. of the muriatic acid gas evolved; they may adopt any chemical means they prefer for this purpose, innoxious in other respects; but the required result may be enforced by an inspector. Not more than five per cent. of the gas is to be allowed to find its way into the atmosphere. Dr. Angus Smith, the inspector appointed by the Government, reports that the Act is working well. Two soda manufacturers in the Tyne district have expended £10,000 each in the construction of the necessary apparatus and appendages; and as new markets have been found for the muriatic acid produced, the capital sunk will soon be restored, and that which was a cause of evil will now be a source of profit.

Equal success has not attended the endeavours to utilize the alkali waste, the sulphuret of calcium which falls down as a solid residue during the manufacture of soda. What to do with it, is a sore puzzle to the manufacturers. Nobody will buy it, nobody will accept it as a gift; it must not be thrown into streams or sewers; and therefore the manufacturers are obliged to buy land near the works, often at £1,000 per acre, for the sole purpose of depositing this refuse in heaps. Tens of thousands of tons of this waste are produced and heaped up as refuse annually; a dirty yellowish earthy substance which gives forth offensive emanations, takes fire occasionally, and pollutes the neighbourhood when washed down by heavy rains. No useful application of the waste is known in its earthy form; but if the sulphur could be separated from the lime, the former would have an immediate money value. According to one estimate, 40,000 tons of sulphur, worth £300,000, is contained in the waste heaps produced annually. Many chemists and manufacturers — Gossage, Leighton, Townshend, Jullien, Noble, Dieuze, Schaffner, Mand, and others—have devised modes of extracting the sulphur; but, unfortunately, the expense has hitherto been so great as to leave no profit on the adventure.

Further Proceedings, to 1872.

The Government and the legislature, as might be expected, were not satisfied with relying solely on the Act of 1862: seeing that the provisions of that statute applied to the one subject of the fumes arising during the soda and alkali manufacture, and scarcely treated of any other nuisance or source of injury. Many isolated facts were brought to light by the committee of 1862, besides those which led to immediate legislation. When Muspratt's chemical works were established near Liverpool, several years earlier, Everton was a kind of West End to that busy place, a locality for the villas of well-to-do Liverpool men; but the chemical fumes extended to Everton, the vegetation was destroyed, the inhabitants gradually moved away, the value of the property lessened; whereupon the proprietors supplanted the villas with dwellings of a humbler rank; and although the chemical nuisance was removed in the course of years, Everton did not recover its gentility. Mr. Lowthian Bell, one of the leading manufacturers of Newcastle, estimated that the Tyne district used up 1,000,000 tons of coal in a year, containing more than 10,000 tons of sulphur, the fumes of which ascended and poisoned the air. (If the quantity were so large in 1862, it must be very much larger now in 1874.) At Smethwick, one of the towns in the "Black Country," the state of the air was such as to kill most of the vegetation in the vicinity, and was deleterious to the health of the inhabitants. The owners of the chemical and metal works did not like to admit the fact; but they showed their belief in it by living at a distance from their works, which their workpeople were not able to do. Near Lichfield was an artificial manure factory, which gave forth a stench of boiling bones, and attracted flies that annoyed cattle in the neighbourhood; but as the works were just outside instead of inside the municipal boundary, the corporation could not interfere, while the county declined to put in force the Nuisances Removal Act; and so the cathedral city had to bear the offensive effluvia for which it was not responsible. In the copper-smelting works of Swansea and Neath, there were two modes of getting rid of the sulphur which copper ore nearly always contains. The *dry* way, as it was technically called, consisted in roasting the ore in reverberatory furnaces, admitting atmospheric air, allowing the sulphur fumes to form sulphurous acid gas by combination with the oxygen of the air, and to dismiss this gas to ruin the vegetation for miles around. The *wet* way consisted in converting the ore into a crude sulphate of copper, dissolving it, and precipitating the copper as a film on iron plates, from which it could be removed; the sulphur was left in the form of liquid sulphuric acid, instead of deleterious sulphurous acid gas. The vegetation in the neighbourhood showed that the wet way was not so noxious as the dry; but (an all-important but) the manufacturers found that it was more expensive to work, and so they did not countenance it.

Report of the Commons Committee, 1873.

The most recent of the inquiries into this subject, made through the authority of Parliament, related to a particular group of trades connected in various ways with the slaughtering of animals, and the disposal of the produce therefrom. A committee of the House of Commons was appointed in 1873, "To consider the operation of clauses 55 and 56 of the Act 7 and 8 Vict., cap. 84, and the best means of making provision concerning the offensive or noxious businesses therein specified." The statute adverted to, passed in 1844, was the Metropolis Buildings Act, relating to various matters connected with public health and safety. The clauses mentioned applied to the trades of blood-boiling, bone-boiling, fellmongering, slaughtering, soap-boiling, tallow-melting, tripe-boiling, and "any other like business offensive or noxious." The trades, as we have said, all refer to the manipulation of slaughtered animals and their products. The clauses were stringent against the erection of such factories or premises within a stated distance of inhabited dwelling-houses; establishments already existing were not to be compulsorily disturbed during a long period of time; but after the lapse of thirty years all were to be pulled down, or the manufacturing and other operations removed to thinly-populated districts. Most of the clauses of the Act have been repealed, from time to time, or incorporated with other statutes in a modified form; but it remains true that the above-mentioned clauses have *not* been repealed, and that the thirty years expire in the present year—1874. The questions have arisen, What is to be done? Shall we enforce the statute? shall we repeal it? or shall we allow it to lie in abeyance, like so many other Acts of Parliament? The committee was instructed to furnish the legislature with information and advice on the subject; and such has been done.

Among the numerous witnesses examined, the Officers of Health were mostly favourable to the removal of noxious trades from populous neighbourhoods; while the owners of the implicated establishments, almost to a man, protested against such a course. Self-interest was closely touched here; seeing that, as no compensation would be allowed, a man might be almost ruined by compulsory removal to, and building new premises in, a distant spot.

The first point of inquiry related to abattoirs and slaughter-houses. It appears that there are no less than 1,500 private slaughter-houses in the metropolis, mostly behind butchers' shops. There are abattoirs—public slaughter-houses—built on a definite plan, at the Islington and Deptford cattle markets; but the butchers do not make much use of them; they prefer either to slaughter live stock on their own premises, or to buy country-killed meat at the Smithfield dead-meat market. The butchers protested, before the committee, that there is nothing noxious in slaughtering healthy animals; and the committee came to an agreement with this opinion. The inspection of all slaughter-houses within the metropolitan limits is provided for by a later statute; and if the inspection is systematically carried on, it is believed that the public slaughter-houses need not be a great nuisance, although they are certainly associated with circumstances not very welcome to the neighbours. It is calculated that £200,000 would be required to build abattoirs in sufficient numbers in the less populous districts, in the event of the 1,500 private slaughter-houses being suppressed. The knackers, or horse-slaughterers, carry on a much more offensive trade. The horses are worn out, diseased, or incurably injured, when consigned to the knacker; and decomposition arises more speedily in such cases than in the slaughter of live stock for human food. More than 7,500 horses are slaughtered, cut up, and boiled annually at one establishment alone, in Maiden Lane, King's Cross; most of the flesh is boiled into meat for cats and dogs; there are many unsavoury processes applied to the blood, bones, intestines, hides, and hoofs; and altogether the odour is very repulsive. But this establishment, and six others of a similar kind in the metropolis, were built when the several districts were thinly populated; and it becomes a question whether the owners ought to be mulcted, merely because builders have, as time goes on, chosen to erect dwelling-houses close at hand.

Fellmongering, one of the offensive trades named, is the removal of wool from sheep and similar skins, and the cleansing of the felt or membrane from bits of fat and offal. Fermentation is necessary to facilitate this removal, and the putrid exhalation is repulsive to olfactory organs not accustomed to it. The fellmongers are all in near vicinity to the skin and leather market at Bermondsey; and the Bermondsey folks, speaking generally, seem willing to put up with the discomforts rather than see the trade driven away by the sanitary authorities.

Tallow melting consists in bringing tallow, fat, kitchen stuff, &c., into a condition fit for the soap maker and the candle

maker. The tallow melters admit that the odour given forth is repulsive; but they contend that it is not unhealthy, and throw the onus of proof to the contrary on their neighbours. Soap making is less offensive than tallow melting. All the manufacturers alike, with a few exceptions, appear to have been ignorant that the statute of 1844 was hanging over them; when they became aware of it, they all protested against its application, and showed how commercially disastrous to them would be any compulsory removal to distant localities.

The offal dealers, tripe dressers, gut and bladder cleaners, &c., cannot possibly conduct their trades in a clean way, nor prevent the dissemination of nauseous odours; but there are degrees in this evil as in others, and supervision will bring about improvements.

The final conclusion of the committee was, *not* to apply the clauses of the Act of 1844, but to recommend a vigilant and systematic visiting of all such premises by official inspectors, with the means of enforcing the inspectors' requirements.

Factory and Workshop Acts.

In order to keep cognate subjects together as much as possible, we have hitherto spoken chiefly of such enquiries and legislation as bear upon noxious trades and processes, mostly those giving forth odours hurtful and offensive to the workers and their neighbours. But we must now notice the labours of forty years, in bringing about improvements in factories and workshops generally, without any thought of suppression or compulsory removal. There can be no question that the various statutes relating to factories and workshops have done, and are still doing, much to lessen the sanitary evils incident to the industrial labour of women and children. The legislature wisely refuses to apply such measures, except in a limited degree, to adult men; seeing that it is the duty of men to settle these matters for themselves. A workman, free to engage or not with a particular employer, in a particular building or shop, may be credited with good sense enough to look after his own health; but women and children are more dependent, and cannot so well protect themselves.

In 1833, consequent on the disclosures made by a Parliamentary Committee of Enquiry, the first Factory Act was passed. It placed a minimum on the age at which young children should be employed in mills and factories engaged in textile manufactures; limited the number of working hours per day; interdicted night-work; specified the minimum period to be allowed for meals, and for holidays and half-holidays; provided for the examination by a physician or surgeon into the age and health of every child before being employed in a factory; enacted that schooling should occupy part of every day, a small deduction to be made from the child's earnings to defray the cost; laid down some conditions relating to the maintenance of cleanliness within the factories; appointed inspectors (or rather empowered the government to appoint them), armed with power to enter all the establishments, and report upon the observance of the Act; and settled the judicial arrangements for punishing those who disobeyed it. Adult women were not brought within the provisions of this statute. In 1834 a short Act was passed to clear up certain doubts which had arisen; but even this did not prevent many of the well-intended plans from being neutralized by such manufacturers as were unfriendly to this kind of legislation. In 1844 a third statute improved many of the provisions, and made some of them applicable to adult women also. In 1846 an Act brought calico-printing into the same category with spinning and weaving factories; in the next following year another Act imposed greater limits to the number of hours' working in each day; and still further modifications, all in the same direction, were made in 1850 and 1853. In 1856 the legislature took notice of the subject of mill-gearing, and empowered the inspectors to enforce the observance of all reasonable precautions for the avoidance of accidents from machinery. In 1861 lace factories were brought within the operation of the several provisions; and, in 1864, another Act extended those regulations which bear upon the sanitary condition of the mills and other premises.

Such were the provisions made by the legislature between 1833 and 1864, regulating the employment of women and children in cotton, woollen, worsted, flax, silk, lace, and similar factories. In 1867 a comprehensive Act was passed, extending the supervision to trades far beyond the range of the textile group. The buildings and trades specified are—blast and other smelting furnaces, copper mills, metal-rolling and forging mills, metal foundries, machine shops, gutta-percha and india-rubber factories, paper mills, glass works, tobacco manufactories, printing offices, bookbinding shops, and, with some exceptions, any premises in which fifty or more persons are employed in manufacturing processes. In all such places the provisions of the Act are to be enforced, so far as concerns women and children employed therein, and the sanitary condition of the shops and rooms; but the Secretary of State is armed with power to make modifications, if it can be shown that the restrictions are too severe in particular cases. Steam, water, or other mechanical power must be employed, in order that the building may be considered a factory within the meaning of the Act. Women and children are not so largely employed in such factories as in those wherein fibres and textiles are worked up, and the regulations for their protection are less extensive and detailed. An attempt is made to meet the evils incident to metal-grinding, by enforcing the use of some kind of ventilating fan to carry off dust and small particles of metal and grit. In 1871 the provisions of the Factory Acts were extended to brick and tile works. Special Acts of Parliament have also been passed relating to mines and collieries, intended chiefly to lessen the liability to disaster.

All the above-named legislative enactments bear relation to large establishments wherein steam or water power is employed, and chiefly to the protection of the women and children employed. We must now glance at those which refer to workshops, as distinguished from mills, mines, and factories.

The Labour Regulation Act, known as the Workshop Act, passed in 1867, contains clauses for the protection of women and children employed in workshops and workrooms, and for the maintenance of sanitary precautions in the rooms themselves. The protective clauses are, for the most part, similar to those in operation in steam-worked factories, and need not be detailed here. In 1871 the House of Commons called for a return showing in what way this Act had worked. In response to this order interesting statistics were collected and published, relating to the trades and the workshops of tailors, stay-makers, dressmakers, milliners, glove-makers, braid and fringe makers, embroiderers, tambourers, hosiery makers, artificial flower makers, feather workers, hatters, cap makers, straw-plait makers, straw hat and bonnet makers, lacemakers, shirt and collar makers, boot and shoe makers, cabinet and furniture makers, rope-makers, coachbuilders, clock and watch makers, tanners and curriers, saddlers and harness makers, soap makers, candle makers, seed-crushers and oil-cake makers, bakers, biscuit-bakers, pastrycooks, confectioners, brewers, distillers, vinegar makers, carpenters, joiners, masons, painters, glaziers, plumbers, lucifer-match makers, the metal trades of Birmingham and the hardware district, and numerous others. The returns related to every county in the United Kingdom, so far as the work of the inspectors and other authorities had gone down to that date. Some of the establishments had steam power, some not; some employed women and children, some not; but the provisions of the Workshop Act were gradually being applied to all in which women and children were among the workers, and which were not so large as to come under the operation of the various Factory Acts.

Among special Acts may be named the Bakehouses Regulation Act of 1863. This statute comprises provisions relating to the cleansing and ventilation of bakehouses, the limitation of night-work in regard to boys and youths, various sanitary precautions, and periodical inspection. The Act is believed to have led to much improvement in the management of bakehouses, especially in crowded districts, but does not interfere with the hours of labour of adult men.

Non-Legislative Enquiries.

It would be discreditable, in a country like England, if individuals and societies left all such matters to the legislature and the state, and made no attempt to lessen by voluntary means the evils complained of. We may suitably notice, without going into matters which would occupy more space than is here available, the direction which such endeavours have taken, in regard to trades noxious to the lungs or injurious to the eyesight.

Several years ago, Mr. Thackrah published a volume relating to the diseases of artisans; in which, among other things, he quoted the remarks made by medical men on the workers in the principal metals. The men in copper-smelting works are affected by the arsenical vapours rising from the crude ore, which sometimes give origin to cancerous diseases. In so far as arsenic is used in paper-staining and glass-making, the men are occasionally subject to headache and sickness. Some physicians think they have noticed, among artisans who work in copper, a peculiar greenness of complexion, eyes, tongue, and even hair, with spare and somewhat decrepit frames; but Dr. Christison, commenting on the opinions of Patissier and Mérat to this effect, states that the health of English copper-workers does not lend support to this view. The brass-melters of Birmingham state that they are liable to an intermittent fever, which they call the "brass-ague," and which leaves them in a state of much debility; an evolution of oxide of zinc is believed

to be the mischief-maker in this instance. White-lead makers and house-painters are subject to what is called the "painter's colic." Many remedies have been suggested and partially adopted; but the best preventive is said to be as much cleanliness of person and of dress as is compatible with the carrying on of the processes. The artisans who work at the quicksilver mines of Almaden, Idria, and elsewhere are subject to terrible diseases, owing to the insinuation of the mercurial fumes into the system. One of these diseases is called by the French "tremblement mercuriel," *i.e.*, mercurial trembling. In England these ailments are felt only in a moderate degree, by glass-silverers, metal-gilders, thermometer and barometer makers, all of whom use quicksilver. As a proof of the subtlety with which mercurial vapours enter and poison the system, it may be mentioned that, when a merchant ship was bringing to England a large quantity of quicksilver in 1810, an accident caused many of the strong leather bags to burst; the whole crew became salivated by the vapour, many were dangerously ill and two died, while the sheep, goats, dogs, cats, &c., were likewise destroyed by the gaseous poison. So far as regards artisans who have frequently to use quicksilver, as in the trades above named, the best preventive of its effects is believed to be a kind of draught furnace, by which the destructive vapour is carried up and away from the workshop. Workers in gold are exposed to vapours, some of which are pernicious, such as that which arises from the fusion of saltpetre and other ingredients in dry-colouring; this produces distress in the head and the nervous system. The evils are aggravated by the cramped posture in which the men sometimes work.

Many well-wishers to the working-classes occasionally find their plans thwarted by those whom they are intended to benefit. It is unquestionable that difficulties arise in the attempt to render manufacturing processes less noxious or insalubrious from the opposition of the workmen themselves. Instances are known in which workmen refuse to adopt remedial measures under the belief that the employers would lower the wages if the work were rendered less dangerous or less repulsive. At Sheffield one of the processes always going on is the dry grinding of forks on a revolving stone formed of hard grit; the face and head of the grinder becomes enveloped in an atmosphere filled with small particles of steel and stone. So injurious is this to the lungs that most of the fork-grinders are carried off before middle age by lung disease. The same thing occurs in needle-making, where a workman will grind the points of 10,000 needles per hour; he is inhaling steel and stone all day long. About half a century ago the Society of Arts offered a prize for the invention of any apparatus that would prevent the entrance of the small particles into the mouth. Mr. I. H. Abrahams responded to this appeal by the invention of a mouth protector. A small frame is tied across the mouth, covered with crape studded with small magnets; air for breathing can enter through the meshes of the crape, but the magnets attract the steel particles and prevent them from entering. There is also a screen so suspended from the ceiling as to shield the workman from the greater number of particles of steel and grit, leaving a smaller quantity only to be dealt with by the mouth-shield. Medical men pronounced the invention to be effective, but the needle-pointers and fork-grinders refused to wear the shield; they would rather have the grinders' asthma, which begins when the workers are quite young men, and carries them off before they are well advanced into middle life. Generally speaking the employer provides some sort of screen, similar to the second invention of Mr. Abrahams, at a short distance in front of the workman's face, with a funnel to carry away the particles in another direction; while the workman simply ties a handkerchief round his mouth. All this refers to dry-grinding; in wet-grinding, for numerous other articles of steel and iron, the particles and the water mix into a kind of mud, which is not notably detrimental to health.

We pass now from a consideration of the lungs to that of the delicate organ of sight.

Many branches of employment are injurious to the eyesight, either in producing dimness and aching at the time, or in bringing about decay and disease in after life. Some years ago, the Society of Arts, recognizing the importance of this subject, appointed a committee to examine into it. The three members of this committee—Dr. J. K. Chambers, Mr. Simon, and Mr. Twining—prepared a report, in which they treated separately of eye maladies incident to particular trades, and those due rather to injudicious management.

Employments unquestionably hurtful to the sight comprise, among others, the following:—Smelters, glass-blowers, and assayers suffer from the excess of light in the heated substances on which they are engaged. Metal-turners, fitters, hammermen, cutlers, and some others are liable to have the eye struck with small chips and fragments of metal, often red hot. Actual sparks are still more dangerous to foundrymen and blacksmiths. Stone chips are a frequent source of danger to quarrymen, masons, stone-carvers, and stone-breakers; very disastrous if the stone be hard granite or flint, which will cut severely. Coke-grit often injures the sight of railway guards, stokers, and engine-drivers. Particles of lime, all the worse if in a caustic or unslaked state, are often detrimental to the eyes of masons, bricklayers, plasterers, hodmen, and lime-burners. The eyes, as well as other parts of the body, are liable to injury from explosions in the employments of miners, firework-makers, rock-blasters, quarrymen, gunpowder-makers, and the users of such substances as dynamite and nitro-glycerine. Small particles of dust, such as chimney-sweepers, millers, mortar-mixers, dustmen, and clay-grinders are constantly exposed to, give much irritation to the eye. Dry-grinders, such as fork-grinders and needle-pointers, are exposed to the action of small particles of steel and stone, which affect the eyes (as well as injure the lungs in the way just noticed). The workers in cotton, woollen, flax, hemp, and jute mills, to which may be added fur-workers and feather-workers, often find that small fibrous particles intrude within and under the eyelids. Soda-water bottlers occasionally suffer from the bursting of bottles, and the dashing up of corks and fragments of cork against the eyeball. Blasts of steam sometimes injure the sight of enginemen. Gold-beaters and book-finishers have the sight to some extent injured by the yellow glare of the gold.

In these and many other cases, the committee had no precise recommendations to make. The liabilities are incident to the processes themselves; and not much can be done beyond advising general caution—a kind of advice which workmen are apt to neglect.

Other injuries to the eye, however, can be either prevented or lessened in frequency; and concerning these, the committee made many useful comments. They can be grouped better according to the sources of injury than to the branches of trade.

Overwork.—The surgeons at ophthalmic hospitals and eye infirmaries find that far more persons suffer from over-use of the eyesight than from external injuries. Needlewomen, tailors, handloom-weavers, copying clerks in law-writers' offices, lace-makers and embroiderers, try their eyesight very severely by close application in a stooping posture during many hours of the day (and often night). These kinds of work are not injurious in themselves; the evil results from long hours. Tailors suffer from this; but they suffer also from the prevalent use of black cloth for men's garments, black work being more trying to the eye than white or coloured if long continued; while the want of fresh air in their heated workshops leads to catarrhal ophthalmia when they go into the open air. The natural remedy for these evils is obviously a lessening of the hours of strain upon the eyesight, coupled with improved ventilation. So far as concerns the labours of women and children, the inspection under the Workshop Act is gradually leading to good results; but the work of adult men must be left to their own good sense to manage.

Excess of Light.—When many hours of evening work are done by gaslight, the eyes are much tried by the strength and glare of the flame. This is often experienced in large tailoring and dressmaking establishments, and in the shops of watch-makers and engravers—especially when, as in the last two cases, magnifying glasses are used. The glare of furnace-light and fire-light is felt by smelters, founders, blacksmiths, cooks, enginemen, and stokers. Haymakers, harvesters, and sailors know from experience how dazzling sunlight distresses the eye. In all these cases, prevention is impracticable; but a lessening of the evil may be effected by judicious arrangements.

Deficiency of Light.—Just as the delicate organism of the eye protests against exposure to more light than is necessary for the work in hand, so does it object to a deficiency, which leads to a straining of the focalizing power. When tailors and dress-makers work in large establishments, they are (as we have just said) often exposed to an intensity of gaslight; but when working at their own homes, they too often make one tallow candle suffice in the evening, giving out a light insufficient for the purpose. Mr. White Cooper, surgeon of St. Mary's Hospital, states: "I have invariably found that a general mourning increases the number of applicants for relief at the ophthalmic institution to which I am attached, owing to the blank, dreary, wearing, wearying obscurity of the light from black work. Fine work has some such effect as dark work upon the sight; for the eye aches in the endeavour to appreciate each minute spot on the work to be done." The evil suggests its own remedies, so far as they can be applied—more light and fewer hours of work.

Badly-applied Light.—The light to which a workman is exposed may be neither too much nor too little; yet, if badly applied, it will distress the eyesight unnecessarily. There may be a flickering motion in the flame of a gaslight, or it may be at

too low a level, or it may be unrelieved by sufficient colour. It is known to the Chinese embroiderers—who often produce exquisite work—that the eye feels the comfort of having a greenish tint diffused through the room by means of green blinds and curtains; and ophthalmic surgeons recommend this custom to the attention of dressmakers, lacemakers, and needlewomen generally. It is also advantageous to change, as frequently as may be, the colour of the cloth or textile wrought upon.

Numerous other sources of injury to the eyesight admit of no precise classification. Shoemakers, for instance, especially the humble cobblers, often damage the sight irretrievably by smoking short pipes when at work; with stooping head, the eyes are just over the pipe, and get more than their proper share (if there *is* a proper share) of the tobacco smoke.

The committee of the Society of Arts made several useful suggestions tending to lessen many of these causes of injury to the sight. Physicians say that beards and whiskers tend to arrest some of the dust and particles that would otherwise reach the eyes, besides having a strengthening and tonic influence on the nerves of the face and eyes; they are useful in this way, but should of course be kept clean. Goggles, wire-gauze spectacles, and other forms of eye-protectors are known to be advantageous to men employed in various trades where dust and fine particles are unavoidable. Frequent laving of the eye with clean water is in many cases a most useful practice. Daylight work instead of gaslight or candlelight, wherever practicable; reflecting screens or shades over gas and lamp glasses, to throw down the light on the work instead of into the eyes of the worker; as frequent changes as possible in the size and colour of the articles worked upon; an avoidance of too long working at one sitting; avoidance, when practicable, of black work and artificial light—these are remedial measures, obvious enough, to lessen, at any rate, the evils complained of.

PRACTICAL PAPERS ON DESIGNING MACHINERY.

(III.)

IN our last paper we had worked out all the leading calculations for the pumps, and before going into the consideration of the proportions and strengths of the details, it may be as well first to complete the calculations already worked out by investigating those for the boiler which is to supply steam to the engine. Boiler engineering in itself forms a most extensive field, and its study and practice involve the operations of some of the most occult laws of heat and of matter. While, on the one hand, therefore, it is requisite to explain to our student readers a few of the first principles of the laws of heat and steam, it would be beyond the scope of these papers to attempt to treat of the whole subject in anything like an exhaustive manner; but we trust to be able to put before them enough to give them a tolerably clear conception of the points that demand attention. Of heat and what it really is, little is known with absolute certainty. Such men as Faraday and Tyndall have studied the matter deeply, and the best-received theory of heat is that it is a species of motion which is called into action between or amongst the particles or atoms composing a piece of any substance. According to this view, the various atoms, say, composing a bar of iron, have a certain motion or movement about each other when that bar is at a particular temperature, the addition of enough heat to raise the temperature one degree increases the motion, a further addition gives a further motion; and as the law of centrifugal force influences the movement of these atoms, when a certain amount of heat is added to the bar, the motion becomes so great, that the centrifugal force overcomes the mutual attraction they exert on each other, and the atoms fly apart, and take up a new position mutually to each other, and the metal becomes liquid, or, as it is commonly called, melted. To give a familiar illustration of the action to our readers, we will suppose a musket bullet to be cleanly cut down in half; if the cut faces are brought accurately together, the capillary attraction will unite them so firmly, that to all intents the ball is as solid as though it had never been cut at all. Well now, if a cord be fastened to the one portion of the split and re-united ball, and the ball be whirled round and round as though in a sling, then as soon as the speed becomes such that the centrifugal force exceeds the cohesive attraction of the cut faces, the disengaged part will fly from the part held by the string. A lowering of temperature has an effect, of course, exactly the reverse, and, as applied to the molten metal, means really that the motion of heat is diminished, the centrifugal force reduced, and the atoms, or, as they are sometimes called, molecules, approach nearer to each other, and the fluid becomes a solid. The alteration in the size of a piece of any given substance, due to the application of heat, and commonly known as expansion or contraction, is due to greater or less distance existing between the atoms proportionately, as the temperature and —according to some authorities—consequent amount of centrifugal force between them operate; while, according to other authorities, the expansive action is due to some repellent action of the heat, which, thrusting itself as it were between the atoms, forces them apart. These points are, however, too subtle for professedly elementary papers; but such of our readers as are desirous of investigating the matter more deeply, cannot do better than read Tyndall's work on "Heat considered as a Mode of Motion," and also a treatise on heat by Mr. Thomas Box. We can only in these papers briefly indicate the working of the laws of heat as regards mechanics. The first thing then that we must impress on the minds of our readers is, that the two things —heat and work—are convertible; that is to say, that when work is done, heat is absorbed, and can only be regained by undoing the work, and the relative values of the two are absolutely unchangeable—a given quantity of heat will, when absorbed properly, give a particular amount of work, and *vice versa*. It is absolutely impossible to do the smallest amount of mechanical work without expending a portion of heat, and the undoing of that work will restore that heat again. This is a point to which the student of mechanical engineering cannot give too much study and attention: unless he be well acquainted with the principles of the laws of heat in its relation to work he will never be anything but a mere copyist and compiler of the designs of other mechanics. On the other hand, while of course the more subtle questions about heat, its laws and characteristics, are occult and hard to master without arduous study, still heat and its laws in relation to mechanics are not so very difficult a study; the great point, however, is for the student to take care and secure a set of links in the chain that fit each other, and constitute a continuous thread,—the curse of many men in this respect is that they have been taught disjointed scraps of knowledge. The knowledge of any science is like a parcel of links of a chain, no two of these links alike, but each having its two ends made to fit the extremities of certain other links. When the chain is correctly put together, it is symmetrical and perfect; and even if a man have not all the chain, he may try to secure as many of the first links as he can, and even half a dozen such, if all fitting and making a perfect chain, are of real value and service to the owner; whereas, if a man have twenty links, all of them odd ones, they are practically useless to him; and while, on the other hand, we consider it out of place in these papers to attempt to put the entire chain of the doctrine of heat before our readers, we will yet try to put them in possession of as many links as will make clear to them the relations existing between heat and mechanical engineering.

In our first paper we impressed upon our readers the importance of having the power to measure the quantities and speeds, and sizes and weights, concerned in designing any machine to perform a given piece of work, and the same necessity exists in respect of the heat which is to work a machine. Now, although heat is, as we have stated already, generally believed to be only a sort of motion existing in the atoms of a body, this motion or heat is admeasurable in two ways: it is admeasurable in quantity and also in intensity. In respect to its quantity, that is measurable on the comparative or proportionate system, even as is weight; thus the term lb. has no intrinsic meaning of its own; it is merely a unit, and then, by multiplying such a unit and attaching a title to a given number of such units, we get such terms as stone, cwt., ton, &c. The same rule applies to heat. Thus, if we take a pound weight of water, at a temperature of, say, 40° of Fahrenheit's thermometer, and burn a lamp beneath it until it is 41°, then a certain quantity of heat has been added to that pound of water. We may apply that same quantity of heat, and store it in a pound of lead, of gold, of mercury, of glass, or of any other substance, and in proportion to the capacity of each for heat will that heat affect the thermometer. Thus, for example, for the sake of convenience, the quantity of heat necessary to raise the temperature of one pound of water at 32° F. one degree, is called a unit of heat, and we must ask our readers to retain this in their minds, because we shall have occasion more than once to refer to it again. Now, a unit of heat will warm one pound of cold water 1°, but it will not warm a pound of lead to that extent, nor gold, silver, glass, or many other bodies, neither will it warm any two bodies to the same extent; and the difference of temperature caused in different substances by a unit of heat has given rise to the term "specific heat," or, in other words, the capacity relatively of different substances for heat; and the way in which such relative capacities are measured and tabulated, is to mix two bodies of different temperatures

GEMS OF INDUSTRIAL ART.—LARGE CONICAL VASE.

FROM THE HILDESHEIM TREASURES.

XUM

together and ascertain the resulting temperature. For example, if a pound of mercury at 40° F. be mixed with a pound of water at 40° F., the result will not be a mean between the two, but will be 97½°, consequently the mercury will be raised 57½°, while the water will lose but 2½°; or in other words, the quantity of heat necessary to raise one pound of water 2½°, suffices to raise mercury 57½°. This if reduced to simple proportion will read—57·5° : 2·5 :: 1 : 0·04348; or in other words, the quantity of heat requisite to heat one pound of water one degree, will only heat mercury 0·04348 of a degree, and accordingly a table of specific heats has been without difficulty compiled as follows :—

Water	1·000 (or unity.)
Alcohol	0·660
Iron	0·114
Copper	0·095
Zinc	0·095
Platina	0·032

This tabulation forms a most convenient method of measuring the quantity of heat, and without such power of measuring no means would exist of determining whether or not as much work was done by an engine as it ought to do, and we could not take any steps to improve such engine, because we cannot cure a fault till we know certainly of its existence, and can determine its magnitude.

The intensity of heat is a different matter. Intensity as a term applied to heat really means concentration. Thus, if we take a stout glass tube 20 in. long, and seal the one extremity, and fit an air-tight piston to work within it by means of a rod to actuate it, we have at once a ready means of demonstrating the intensity or concentration of heat. Gaseous bodies have their respective capacities for receiving heat, or, shortly, their specific heats, just as have solid or liquid bodies; and, putting the thing simply, if we assume that the diameter of our glass tube is such as will give one square inch of area, the tube will contain 20 in. of air at the density of the atmosphere. Well, now, these 20 cubic inches, at a temperature of 60° F., contain a certain quantity of heat; then when the piston is forced into the tube, the air and its contained heat are compressed into smaller compass, until at last, when the piston is within one inch of the bottom, we find that the quantity of heat contained previously in the whole of the tube is now concentrated twenty-fold and proportionately intensified, though heat is so subtle that it is nearly impossible to retain even a moiety, the greater part of it passes away so rapidly to the surrounding atmosphere. If, however, a thermometer be put in contact with the air contained in the tube, it will be seen to rise accordingly as the air is compressed. On the other hand, if, after the air in the tube has been compressed twenty-fold, it is allowed to stand a short time, its temperature will fall to that of the surrounding air; and if now this end of the tube be wetted on the outside and the piston quickly withdrawn, the wet on the tube will instantly freeze in a hoar of ice-crust on the glass, simply because the amount of heat in the twentieth part of the tube is now divided or distributed twenty times, and the frost is the result. Now, the quantity of heat contained in 20 cubic inches of air at 40° F. can be obtained by the combustion of a certain weight of carbon, by causing the combination of that carbon with its chemical equivalent of oxygen, and that quantity of heat may be exchanged for a certain quantity of work done in the way of lifting weight or overcoming friction. And we must exhort our readers to bear in mind that all work to be done consists, first, in the storing up of a certain amount of work or force in overcoming the *vis inertiæ* of any body sufficient to give it a particular velocity. A familiar illustration of this may be given in comparing the process to a person desiring to take a season ticket on a line of railway. Besides the price he pays for the ticket, he has also to lodge a small sum as a deposit, and so long as he continues his subscription he never gets his deposit, but whenever he ceases his subscription, and he gives up his ticket, he gets back his deposit.

Taking this in another way, suppose a fly-wheel, whose nave or centre boss and spokes weighed nothing; that the diameter over the rim was 5 ft., and the weight of the rim 10 tons. Suppose, too, that the wheel could be moved without any friction; then to cause that wheel to rotate at one hundred revolutions per minute a certain amount of force must be exerted and expended in pulling it round till it attained the requisite velocity; having attained it, however, the wheel would rotate for ever, there being no friction to stop it, but if on the one hand it went no slower, on the other hand it would go no faster unless more force were expended to accelerate its movement, and a certain amount of force being added, then, instead of making one hundred revolutions it would make, say, one hundred and five. As friction can never be quite done away with in practice, then as soon as force is withdrawn from the wheel it begins to draw on its deposit by degrees, whereas the railway ticket holder gets this all at once, so in that sense, the simile may seem imperfect, but it is not so really, for if some obstruction were suddenly interposed the wheel would be instantly arrested, all the stored-up force being at once expended in a single supreme strain; left however to itself, the wheel gradually expends all the force stored up in it in overcoming the resistance of the air and that of the journals or axle bearings. The second thing, representing work done, is overcoming gravity to speak scientifically, and, in everyday plain-speaking, is in lifting weights. The third is in overcoming friction. Of these three, the first is not work given away, it is only lent, and is always regained exactly to the last atom, while the other two represent actual exchange of one commodity for another; thus if we seek to raise a certain quantity of water, as is the case with our tank and well and pumps, we simply pay a certain price of heat, and the water is placed in our tank; on the other hand, if we decide to let the water in the tank return to its original place in the well, Nature is so even in her dealings that we will receive back exactly to a hair's breadth the heat expended in raising it. Of course this is speaking purely theoretically; all Nature's laws have been made by the great Creator of the the universe, and therefore cannot err, but when we come to use the term "in practice," man's imperfect state is at once acknowledged; and thus while as a fact the same power, as represented by some force we call "heat," is restored by the replacement of the water, in practice but a portion of it is thus available usefully to us, because in raising the water more than the merely theoretical amount of heat necessary was expended, the excess being absorbed in overcoming friction of one sort or another, and wasted by leakage; such expenditure being attributable to our imperfect knowledge of how to apply properly the laws of our Creator to our purposes here.

Now to make perfectly clear to our readers the convertibility of heat into work and of work into heat, and also to make clear the relations of the laws of combustion, evaporation, and of work done in a steam engine, such as that to drive our pump, we will proceed as follows: If a lead ball weighing 1 oz. be taken on a day when a Fahrenheit's thermometer secured to the window casement shows a temperature of, say, 70°, the ball itself being of the same temperature, and dropped on a flag-stone or other hard inelastic substance, situate 20 ft. below, and instantly tested by a thermometer having say a cup receptacle at the mercury, so that the whole surface of the ball is made to show its temperature, it will be found that the mercury will rise a certain number of degrees, the number being easily determinable by calculation, on the joint principle of specific gravities and specific heats. The various laws of natural philosophy are so interwoven through each other, and depend so much mutually on each other in their several operations, that it is not easy for us on the one hand to adhere closely to our intention to put before our students the complete chain of links on which the operation of our pumping engine and the boiler to drive it depends, and yet on the other hand to retain that simplicity and clearness which we desire so earnestly to retain, knowing as we do how an entire treatise on any subject becomes merely so much "letterpress" to the student if once he meet a stumbling block; he goes on very well perhaps through a third of the work, and then some obscure or imperfect sentence, some printer's error, perceptible enough to one accustomed to book study, throws the student off the track, and he is brought to a dead lock. Now without going into a learned analysis of the subject of the relative densities of bodies, we may just state that even as every body, whether it be solid, fluid, or gaseous, has a certain proportionate capacity for heat, so also it has a certain weight as compared with its bulk, and such weight is termed its specific gravity. Water is taken as the standard and is written in the table as 1, then follow all those other bodies which have been weighed, and the table annexed shows the specific gravity of each.

Specific Gravities.

Distilled water at 39°	1·000
Proof alcohol	0·916
Cast iron (average)	7·230
Copper „	8·780
Cast zinc	7·000
Sheet platinum	23·000
Lead	11·360

Now to return to our lead ball: if its specific gravity be compared with that of water we see from the table that it is more than eleven times as great; then the work done, or the heat given to the ball in return for the work it has done in falling the 20 ft. would exactly raise 11·36 ozs. of water to the altitude from which the lead ball fell: the weight of lead that fell and the weight of water raised, neglecting loss from friction

and other sources of waste, will be identically the same, but the bulks in cubic inches or cubic feet will be different because of the respective specific gravities of the two bodies; the specific gravity of the lead is much greater than that of the water, and consequently a less bulk of lead is raised by the same expenditure of work or heat.

We have shown that the fall and sudden destruction of motion of our lead ball raised its temperature so many degrees, and that this quantity of heat would exactly restore it to its original place; we must in our next paper proceed to show the application of this to our pumping engine, and meanwhile we would exhort our student readers on the one hand not to try and cram the whole of the knowledge we have tried to impart to—or rather put before—them, all at one reading into their brain, but to read and think over it and then in a day or two again read and again think over the gist of the paper, and digest it mentally; the mind wants time to digest food just as much as the stomach, and until one meal is digested it is vain to set on another, and if a point or link in any one of these papers is obscure or not clearly understood by either of our readers who reads with a real desire to master the subject, he has but to write to us and propound his difficulty and we will try and make the thing clear to him.

THE BRITISH ASSOCIATION AT BELFAST.

(*Concluded from p.* 168, *No.* 21.)

September 1st, 1874.

FROM among the papers, which were read in the chemical and physical sections since I despatched my first report, the following may be considered as interesting to the readers of this magazine :—

On the composition of an inflammable gas issuing from below the silt bed in Belfast, by Dr. Andrews.—In sinking for a well upon the premises of Messrs. Cantrell and Cochrane, in George's Lane, Police Square, Belfast, after having passed through a deposit of silt to the depth of 33 ft., a layer of gravel was reached, 7 ft. in thickness, and containing a quantity of organic *débris*. It rested upon a thick deposit of very tenacious clay. On entering the gravel bed, a large flow of water occurred, which rose to within 4 ft. of the surface of the ground, and interrupted the operation of boring, till a pump, worked by a small steam-engine, was erected, which, so long as it was in action, kept the boring free from water as far as the surface of the gravel-bed. A workman, having lowered a light to examine the bottom of the well, was surprised to see a lambent flame playing over the surface. On examination, this was found to arise from a disengagement of inflammable gas, which had accumulated between the lower surface of the bed of silt and the layer of gravel. An iron pipe, terminating in a funnel-shaped mouth, about one foot in diameter, was now sunk till it reached the gas stratum, and the water in the well was kept by pumping at such a level that an extra pressure of about one inch of water was maintained upon the gas below. The gas now flowed freely, at the rate of about 40 cubic inches per minute, through the upper end of the iron pipe, and when ignited burned with a yellow flame, which could scarcely be distinguished from that of ordinary coal gas. Two portions of the gas were carefully collected by displacement, the stream of gas being allowed to pass till the whole of the atmospheric air in the vessels was completely swept away. The connecting tubes were then carefully sealed, and the gas was afterwards analysed in the laboratory of Queen's College. A measured volume of the gas, standing over mercury, was exposed to the action first of caustic potash, and afterwards of pyrogallic acid, and the residual gas was afterwards analyzed. From the data thus obtained and the results of the previous action of the caustic potash and pyrogallic acid, it was shown that the composition of the gas was :—

Marsh gas	83·75
Carbonic acid	2·44
Oxygen	1·06
Nitrogen	12·75

The density of the gas (air = 1) was found to be 0·661, which corresponds nearly to the foregoing composition. The gas was inodorous and contained no compound of carbon and hydrogen except marsh gas. From this analysis, it is evident that the gas formed in this subterranean sheet of water is in all respects the same as that which is produced in stagnant pools containing leaves and other vegetable matters.

On Gold Assays.—W. C. Roberts presented the second report of the Committee on Gold Assays. The committee pointed out the importance of procuring minute accuracy in assay reports to assayers generally, as well as of its being of great importance in the commercial relations of this country with other nations. They further showed that extreme accuracy in the composition of alloys employed for coinage was the only possible basis upon which an international coinage could be established.

Dr. Gladstone, in remarking on the report, expressed a hope that the committee would soon be in a position to make some statements with regard to the use of the spectroscope in quantitative analysis, upon which subjects experiments were actively pursued in the Mint.

An improved form of a filter pump.—The advantages claimed by the inventor, W. J. Lovett, for the pump are its practical efficiency and portability, and also its non-liability to get out of order. It consists of a metallic cone provided with a convex metallic cover; to the apex of the cone is fitted a tube for carrying any waste water, and in the middle of the convex cover is fitted a tube which goes down nearly to the apex of the cone, and at this end is fixed a jet formed by soldering a square pyramid of brass in the end; the pyramid has a hole through its centre which points straight down the exit tube. The square pyramid being fixed on a round tube leaves four orifices for the water to pass through, thus forming a rude rose jet, and the centre hole serves as a jet to drive back the air caught by these four orifices straight down the waste pipe. The upper tube being connected with a good force of water, the rose exhausts air from the cone, and drives it down the waste pipe. One of Professor Thorpe's valves is fitted to the convex cover, and a tube connected with this is fixed to the filter as required. The time of filtration is reduced to about one-sixth on the average. The pump supports as a rule 15 or 16 in. of mercury; this, of course, varies with the fall of water obtainable. With a good fall of water results as high as 20 in. have been obtained. The apparatus may be used as a respirator for drawing a current of air through the apparatus. It may also be used as a water blowpipe by attaching the waste pipe to one of the holes of a three-bored cock; into the other holes are fixed a tube going to the blowpipe, and a tube with adjustable orifice for carrying any waste water.

On an Aspirator, by Dr. Andrews.—In this aspirator, the current of air is produced by raising a cylindrical vessel, open at bottom, and immersed in water, contained in the outer vessel. The tube communicates with the inner and upper part of the cylindrical vessel. The construction is exactly the same as that of the gasometers which are used in the preparation of gas for illuminating purposes on the large scale. In order to raise the cylindrical vessel, it is connected by means of a brass rod with the free end of a chain of a common one-day German clock, whose weight is increased so as to enable it both to move the machinery of the clock, and also to overcome the resistance of the cylindrical vessel. By this means the cylinder is elevated at a perfectly uniform rate, which may be varied at pleasure, by augmenting or diminishing the length of the clock's pendulum. When the cylinder has attained the proper height, its motion is arrested by a nut, the clock being at the same time stopped; to prepare for a second operation, the clock weight is removed, and the stopcock closed and opened, and, by applying a gentle pressure to the top of the cylinder, or laying a small weight upon it, the cylinder is made to descend. It is very easy to determine by experiment the precise volume of air which enters the receiver during its ascent; and if the apparatus be carefully constructed, no appreciable error will arise from inequalities in the volume of air entering the cylinder in different observations. It is easy to calculate the volume of air at a standard temperature and pressure which has passed through the apparatus. If the aspirator be applied to the determination of the amount of aqueous vapour, or other absorbable constituent in the atmosphere, it will also be necessary to find the mean temperature and pressure of the air during the course of the experiment. With these data, a simple calculation will give the exact weight or volume of the aqueous vapour in the air. It is unnecessary to point out the many applications which an aspirator affording an absolutely uniform current of air may receive. In the chemical laboratory it will frequently be found a very convenient instrument of research, and may even be applied in some cases to quantitative experiments. But it is chiefly in atmospheric inquiries that this aspirator will find its applications; and in the determination of the amount of oxygen, carbonic acid, aqueous vapour, and even ammonia in the air it will prove a useful addition to the meteorological observatory. For these objects its size and form will require to be modified; and it will

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be necessary where large quantities of air are operated upon to enlarge considerably its dimensions, and employ more powerful clock machinery.

Professor Hodges gave an interesting account of the composition of tea and tea soils from Cachar. He said:—Notwithstanding the important place occupied by the tea plant in the dietary of so large a portion of the world, its chemical examination has attracted comparatively but little attention. We owe to Peligot and Mulder the most valuable investigations which have been made in connection with it; and more recently we have been supplied with some analyses of the ash of teas from the laboratory of Professor Horsford; while Wanklyn and Allen have lately contributed many facts of great value in reference to the examination of the tea of commerce and the detection of adulteration.

Some time ago, Professor Zöller read before the Physico-Medical Society at Erlangen a paper on the chemical investigation of a Himalaya tea ("Repertorium für Pharmacie," Band xx. Heft 8), which possessed peculiar value, from the circumstance that the specimen examined might be regarded as consisting of genuine tea without any foreign admixture, having been received from the growers by the late Baron von Liebig. Professor Zöller's investigations confirmed the correctness of observations which he had formerly made respecting the influence which the age of the leaves of plants exercised on the composition of the ash, that while young leaves are found to be rich in potash and phosphoric acid, and poor in lime and silica, the amount of lime and silica in the ash increases with the age of the plant. As the best qualities of tea are known to consist, as I shall presently show, merely of the very young shoots of the plant, the estimation of the amount of potash, phosphoric acid, lime, and silica, may be usefully, as he suggested, employed in enabling us to judge of the quality of a specimen of tea. This opinion he found confirmed by the examination of the specimens of Himalayan tea.

One hundred parts of the ash of this tea consisted of—

Potash	39·22
Soda	0·65
Magnesia	6·47
Lime	4·24
Oxide of iron	4·38
Protoxide of manganese	1·03
Phosphoric acid	14·55
Sulphuric acid	trace
Chlorine	0·81
Silica, acid, and sand	4·35
Carbonic acid	24·30
	100·00

The richness of the tea ash in potash and phosphoric acid, showing that the tea had been prepared from young leaves, suggested that the amount of matters in the leaves, soluble in water, and of nitrogen, and also probably of theine, would be large. These anticipations were confirmed by the investigations. The extract obtained by treating the leaves with boiling water weighed 36·38 per cent., and the nitrogen 5·38 per cent., while the theine amounted to 4·95 per cent. of the air-dried leaves.

Some time ago I had an opportunity of submitting to examination specimens of tea grown in Cachar, under the superintendence of Samuel Davidson, Esq., formerly of Belfast, and also a specimen of fine Cachar tea forwarded to me from the same district by Dr. Joseph Nelson. Mr. Davidson's specimens were taken from the fields in August, and were carefully enclosed in tinfoil, and may therefore be regarded as representing genuine, unmixed specimens of Indian tea. Mr. Davidson also kindly supplied the following history of the crop from which the specimens were taken:—"The leaves were taken from plants in their seventh season, and consisted of the young shoots from which tea is manufactured—viz. the bud, the first, second, and third leaves down the stem. In none of the samples were there old leaves or actual wood. A shoot with this number of leaves is usually the growth of about twelve days after the bud has got started to grow. The indigenous sample is from the variety of the plant which was originally found growing wild in the jungles of these districts. It is, I should think, the true *Thea viridis*. It is a very large-growing plant,—almost a tree,—and its leaves, when full grown, are very large and succulent. It yields by far the best quality of tea. The other sample was from a hybrid plant. This is supposed to be a true hybrid, between the indigenous and China varieties, and certainly partakes very much of the peculiarities of both varieties. The China plant is the variety which, I think, is the correct *Thea Bohea* originally imported direct from China. It is a miserable, small-growing, stunted plant compared to the indigenous, the full-grown leaves being only about two inches long, and the tea is inferior. The hybrid gives a good strong tea, and is a hardier plant than the indigenous, and so is very much liked; but the more closely it approaches to the indigenous it is the more highly prized." The specimens received by me had been mainly dried in heated rooms. The produce of the crop was estimated at 400 lbs. of dried tea per English acre. It is so seldom that we are able to obtain any precise account of the history of the specimens of tea and other foreign productions which have been submitted to chemical examination, that Mr. Davidson's report possesses especial importance.

One hundred parts of each variety of the tea gave me the following results:—

	Indigenous.	Hybrid.
Moisture	16·06	16·20
Organic matters	78·81	78·98
Mineral matters	5·13	4·82
	100·00	100·00
Nitrogen in the dried tea	4·74	2·81

The ash of each respectively consisted of:—

	Indigenous.	Hybrid.
Potash	35·200	37·010
Soda	4·328	14·435
Chlorine	3·513	2·620
Sulphuric acid	5·040	6·322
Phosphoric acid	18·030	9·180
Oxide of iron	2·493	2·463
Protoxide of manganese	1·024	0·800
Lime	8·986	5·533
Magnesia	4·396	5·910
Sand and silica	0·500	1·300
Charcoal	2·900	1·830
Carbonic acid	13·590	12·600
	100·000	100·000

I was also enabled to submit to examination specimens of the soil and subsoil from the field on which the tea had been grown. Both soils were of a reddish colour, and in fine powder, the subsoil, which was taken 1 ft. 6 in. below the surface, being rather deeper in colour than the soil. A textural examination of the specimens was made according to the method which I have described in my work on "Chemistry for Farmers," and gave the following result:—

One hundred parts of each respectively were found to consist of—

	Soil.	Subsoil.
Sand in fine powder	71·5	82·5
Clay	28·5	17·5
Carbonate of lime, less than 5 per cent.		

Both soils may therefore be described as sandy loams.

CHEMICAL COMPOSITION.

100 parts of each respectively consisted of—

	Soil.	Subsoil.
Organic matters	4·75	5·18
Chloride of sodium	0·11	0·35
Potash	0·03	0·03
Oxide of iron	6·00	7·20
Oxide of manganese	trace	trace
Alumina	2·02	3·86
Lime	trace	0·10
Magnesia	0·12	0·05
Sulphuric acid	0·07	0·35
Phosphoric acid	0·05	0·03
Insoluble siliceous matters	64·80	56·50
Moisture	22·20	24·44
Nitrogen per cent.	0·158	0·22

The amount of nitrogen and alkalies in the subsoil, it will be perceived, exceeds that which was found in the surface soil. This, I consider, may be owing to the circumstance that heavy rains (40 inches within four months) had fallen for some time before the specimens were taken.

Another sample of Cachar tea, kindly forwarded to me by Dr. Joseph Nelson, was also examined, chiefly for the purpose of ascertaining how far we could rely upon the determination of the amount of matters which are removed by heating tea with boiling water, as indicative of the presence in the tea of commerce of exhausted tea or of foreign leaves.

One hundred parts of the specimen were found to contain 4·963 parts of moisture, and the ash amounted to 5 parts. By treating the leaves with boiling water until exhausted of soluble matters, and evaporating the solution to dryness, an extract weighing 42·4 grains was obtained. Determinations of the amount of nitrogen

in the leaves as received, and also in the insoluble residue were made, and while the nitrogen of the original sample amounted to 4·425 per cent., the insoluble residue was found to contain only 2·109 parts, the amount of mineral matters, by treatment with water, being reduced to 1·56 parts, so that 68 per cent. of the total mineral matter of the tea, and about 58 per cent. of the nitrogen, had been removed in the infusion.

W. J. Cooper read a paper on the composition of some farinaceous foods. A considerable amount of public interest has been excited by the recent investigations of the Adulteration of Food Committee into the nutritious properties of farinaceous foods. These foods are of the utmost importance to children and invalids, whose stomachs are too delicate to properly digest ordinary alimentary substances; and the upper and middle classes are in the habit of using with advantage considerable quantities of such preparations as arrowroot and corn flour. These preparations being in a minute state of division, they break up easily and blend with water without difficulty; and they make the food so gelatinous that the digestive juices can at once attack it. If large quantities of vegetable matter be introduced into the stomach of delicate children it becomes very difficult to digest, but there is nothing to prevent arrowroot, sago, and corn flour from being digested in the case of invalids and children, except in the case of children under nine months old. Excess of substances containing nitrogen has been known to produce diarrhœa in some children as well as in grown-up persons. The nutritious value of starch foods has long been universally recognized. In India, China, Mexico, and some of the South Sea Islands, besides other places, nine-tenths of the food consumed by the inhabitants is mainly starch. In Ireland it is well known that starch furnishes about 80 per cent. of the actual weight of nutriment taken by the peasantry, potatoes only containing some 1½ to 2 per cent. of albuminous matter, and 22 or 23 per cent. of starch, the rest being water. Potatoes and rice are mainly farinaceous, containing only a very small proportion of proteine (or nitrogenous) compounds. Arrowroot and corn flour are also examples of farinaceous foods containing small proportions of nitrogenous material. Of the nutritious and life-sustaining power of arrowroot I can speak positively from personal experience. In England our dietaries are apt to be too nitrogenous, and hence the great value and necessity for assimilative farinaceous food. Out of eight chemists and physicians examined before the Adulteration of Food Committee, one chemist stated that "arrowroot and corn flour had exactly the same nutritive power (that was, the want of it), and that such food was not nutriment in any sense of the word." The innutritious theory, unsupported by facts relating to the substances in question, has been completely shattered by the evidence of an overwhelming majority of authorities, whose experience as medical men, as well as their chemical qualifications, attached additional weight to their testimony. These foods are deservedly popular, and, when mixed with milk and various other substances, have been proved to be highly nutritious. The cases are quite exceptional when water alone is used as an admixture; but even in that extreme case, the nutritious value of such foods is very considerable. A complete dietary has not yet been introduced to public notice in the form of a food for adults. The late Professor Liebig did introduce a food for infants, devised upon chemical principles to form a substitute for mother's milk, prepared from malt flour, wheat flour, cow's milk, bicarbonate of potash and water. This, I believe, is the only artificial example of a complete dietary. Milk stands alone as a complete natural dietary for infants. The complex nature of Liebig's composition, which does not appear to be much used in England, will afford some idea of the difficulties to be encountered in concocting a complete dietary; and under these circumstances, it is fortunate that the views of a chemist, which, if supported, were well calculated to prevent the use of most valuable and important foods for the sick chamber and the nursery, have met with such decided refutation. It would be as idle to complain of the butcher for not selling vegetables as a proper part of the joint, or the baker for not selling butter with his bread, as to raise objections to these starchy foods, which are the most convenient media for conveying by admixture a wholesome amount of nitrogenous substance, modified according to the requirements of children and invalids, who would otherwise be incapable of assimilating ordinary foods.

A self-acting gas generator for the manufacture of aërated waters, invented by J. F. Smyth, was described by W. Smyth. The improvement consists in using a glazed earthenware vessel, which is made self-acting by the pressure of the gas, whereas, under the old system of generating in a lead retort, hand labour was necessary. The cistern or generator is divided into three parts, the upper receiving the acid, the middle the limestone, which rests on a perforated bottom, through which the acid ascends and comes into contact with the limestone, contained in the middle box or chamber. The gas, as generated by muriatic acid, rises through the middle chamber and escapes by a pipe into a purifier, which is regulated by a valve connected with the reservoir, under a moderate pressure; the gas is then brought into contact with the water by means of the soda-water machine. Another, and certainly the greatest, advantage is, that in aërated waters manufactured in this way no trace of lead or sulphate of copper poisons can be found, and they have been pronounced by eminent chemists to be perfectly pure. It was added that the machine could be seen at full work in the extensive aërated water establishment of Messrs. Kirker and Co., 24, Academy Street, who would be glad to show the process to any member of the Association, as given in the published list of places of interest open for visitors.

A paper on the injurious effects of dew-rotting flax, dealt with a subject of considerable local interest:—

The cultivation of the flax plant in the field is not a matter of extraordinary difficulty. Any careful agriculturist who will take the trouble of reading the printed instructions circulated by the North-East Agricultural Society and the Belfast Flax Supply Association will be able to master the details necessary for the growing of the crop. It is the after management that generally embarrasses the farmer, and particularly in those districts where the crop is tried for a first time. The extension of flax cultivation in the British Isles would be very useful to the important industry of the linen manufacture, and would add a remunerative crop to the limited list of the British agriculturist. At present the area occupied by flax is chiefly to be found in Ulster. The present year's return gives 102,789 acres for this province, the rest of Ireland showing only 4,097 acres. I am not aware of any accurate statistics on the subject regarding England and Scotland, but a few thousands would probably cover the quantity of acres they produce. The variation in the number of acres of flax in Ireland is very remarkable. The lowest I can find a record of in this country was in 1848, the number being only 53,863 acres. One of the highest seems to have been in 1863—viz., 213,992 acres. Of course, a short Irish crop causes a large importation of foreign flax, and this leads to extensive payments abroad instead of at home. The first difficulty that meets the inexperienced farmer after his flax is gathered off the field is the steeping process. The celebrated Louis Crommelin (appointed overseer of the linen manufacture in Ireland by King William III.), writing in 1705 on the subject of preparing flax, quaintly says:—"Flax may be prepared without watering by grassing it until such time as the stem corrupts; yet it is better to water it where it can possibly be done without great inconvenience." Now, so far as I can form an opinion, this plan of preparing without watering, commonly called "dew-rotting," is quite unsuited for any but the very coarsest flax, such as would not be spun into yarn used for making bleaching cloth; and my object in writing this short paper is to warn the inexperienced that if once flax be so treated the prices obtained will be comparatively low, and the result, if the article goes to a bleach-field, will be very unsatisfactory. There is something in the process of steeping flax—a process more accurately, perhaps, described by the common expression of retting or rotting—which seems necessary to ensure the attainment of high colour when the prepared fibre is manufactured into cloth, and arrives at the bleaching department. The fermentation, which seems more of a putrefactive character, acts on the juices and gummy matters which cement the woody stem to the pure fibre of the plant, and also not only assists the after separation of these, which is the object of the subsequent scutching operation, but has such a powerful effect on the colouring matter of the fibre as to render the change required in bleaching much more safe and successful. But, though grassing alone is not sufficient to make a proper preparation of good fibre, it is, after the steeping is over, a most useful and necessary addition.

I need not cumber these few remarks with a description of the steeping of flax in the ordinary way. The printed instructions for the cultivation already referred to give ample information also on this point. What I want to call attention to is the fact that the best flax, unless properly watered and grassed, is not likely to prove remunerative to anyone; and I hope that those farmers who reside at a distance will follow the example of those in Ulster, and give some time and trouble to this rather difficult part of flax management. Let the cheaper plan of dew-rotting be never applied, except to rough, coarse flax, and the result will, I feel sure, be more profitable to all concerned. There is another point worth mentioning on the subject of steeping flax; brackish water, such as may be met with in the low-lying districts, near the sea, should be carefully avoided. The result of using such is now, I believe, generally admitted to be injurious to the fibre intended for white linen, and gives a leaden dull colour in many cases to the flax itself. With respect to improvements in the flax-steeping process, there is really very

little to report of late years. The ordinary open-air system is carried on now much the same as when Louis Crommelin wrote in 1705. Various new plans have been suggested, and to some extent tested with more or less success.

So far back as 1808 Mr. O'Reilly, of Belfast, suggested boiling the flax in hot water. Mr. Shenck more recently patented a system of fermenting in large vats, in a crossed building, with water heated to about 80° or 90°, and no doubt this plan worked pretty well. I think if this system could be extended, and grassing in the ordinary way added to it, some good might result; though I should not like to say positively it would be a financial success. The system proposed by Mr. Watt, and in operation for several years, is slightly different. The flax is placed in an iron steam-tight chamber, with a condenser on the top. The steam introduced at the bottom heats and softens the flax, and, being condensed in contact with the roof of the chamber, falls down in water through the flax, washing and cleansing it on its way. The flax is afterwards heavily rolled and dried. This plan may suit for coarse and strong flax intended for making strong threads and linens used in the brown condition; but I think for the fine fabrics that the old method will be more successful in every respect. Mr. Andrews, the Secretary of the Flax Supply Association, informs me that he has successfully tested a plan of fermenting in covered vats, the temperature of the air in the building being increased by steam heat to the required point. If the agriculturist had no other cost and difficulty than the simple cultivation of the flax plant, the extension of the growth of flax would be comparatively easy to carry out. The trouble of steeping and after-management renders the crop less popular than it should be. The advantage of producing on the farm a large quantity of flax seed, so well known for the nutritive qualities it contains, would of itself be an attraction to many intelligent farmers, for there is no doubt by a little skill and care the greater portion of the flax seed can be taken off and preserved for feeding purposes without any injury to the fibre. The time may arrive when a regular extensive business may be taken up in all flax-growing districts by enterprising individuals with the object of buying the flax from the farmers in the green state, and treating it in an improved way on a large scale, combining probably the steeping of the flax and scutching operations in the same establishment. Meantime, let farmers who wish to make profit in growing flax attend as carefully to the watering process as to the field cultivation, and avoid as a general rule the imperfect new rotting system, or the use of brackish water in any of the pools intended for steeping this valuable plant.

In conclusion, I may remark that the present month of August is the time the farmers of Ulster are in the habit of watering and grassing the flax crop; and the air in many localities is so full of the odour arising in these necessary processes that it is possible, if not explained, many of the members of the British Association, who come from a distance, may form a prejudice against our climate and atmosphere. I can assure those strangers, whose presence amongst us at this great meeting we cordially appreciate, that this unpleasantness is of a transient character, and will pass away in a few weeks; while we may reasonably hope that the beneficial effect to science in this neighbourhood, by the scientific contributions and advice of the many talented men met together, will have a permanent and useful influence in years to come.

Professor Herschel read the report of the committee on experiments to determine the thermal conductivity of certain rocks. In the introductory notes on these experiments, published as an appendix (p. 233) in the last volume (for 1873) of the "British Association Reports," the list of rocks selected and the manner of experimenting on them were described. With the exception that sections of Calton trap rock, of a great pyramid casing stone (nummulitic limestone), Caen stone (or Normandy building limestone), cannel coal, chalk, and red brick, were added to this list, and that the apparatus received some small but very important improvements to make it heat tight, the material of the experiments as well as the method of working them remained substantially the same as last year. Instead of a conical tin vessel with 1 lb. of water, a cylindrical one holding 2½ lbs., with an internal agitator and thermometer, was used as the cooler. The opposite faces of the heater and cooler were lined with velvet and each clasped by a caoutchouc collar, which, projecting a little above them, clips the circular edge of the rock plate when it is placed between them, and two small notches cut in each collar also allow the wires of a thermocouple to be introduced, touching the rock-surfaces while the rock is being heated. With the view of traversing the plate with the thermopile in different directions, the piece of stout palladium wire (about 18 gauge) used as the electro-motive element between the two iron wire branches of a delicate reflecting galvanometer, was silver-soldered to the iron wires at its two ends, all the wires being first rolled thin and flat to some distance from the junctions. The scythe or scimitar-blade shape most easily given to the wire in rolling it thin was advantageous in the construction, because, instead of uniting the wires continuously in one straight length and folding the points of junction on opposite sides of the rock (thus confining their range upon it to a single diameter or to one straight line), advantage of the curvature was taken to connect the wires by superposition, instead of by prolongation at their junctions, without overlying each other, into two flat ogee arches, or merry-thought-like blades, between which the rock is held as in a forceps. The straight unrolled parts of the wires are bound very firmly to a square piece of wood, which acts as a handle to guide the points of the forceps to various parts of the rock-faces, while it keeps them securely in their places, and thus allows the small elastic pressure of the wires to clasp the rock gently between the points of the thermo-electric pincette without assistance from the velvet covers. After thus inserting a rock section in the apparatus, protecting the rock and cooler from below with a stout wooden screen, and from loss or gain of heat in other directions by a suitably thick case of woollen stuff and a few bandages of similar materials, the rate of rise of temperature in the cooler, when agitated, was noted by the average number of seconds taken by a delicate thermometer contained in it to rise $\frac{1}{5}$° F. (one graduation on its stem) as soon as this rate of rise was found to have become sensibly constant. About twenty minutes were usually occupied in the beginning of an experiment with waiting for a steady condition of the thermometer readings, and ten or twelve minutes more were required to ensure it and to obtain the average rate of their increase for the rock specimen under observation. The temperature difference shown by the galvanometer at the same time at first rose rapidly to a high maximum and then descended very gradually to a fixed lower reading. The pincette was traversed to and fro over the rock surfaces while the thermometer was being noted, and exhibited during these motions fluctuations answering to about 1° or 2° F. on either side of an average position; corrected for zero of the scale, and reduced by trials for this purpose between every two or three experiments to Fahrenheit degrees, the temperature difference thus formed, divided by the quantity of heat transmitted to the cooler per minute, gave the apparent thermal conductivity of the plate. The results in Peclet's units were scarcely more than one-third of what Peclet and other earlier experimenters had obtained. It was obvious that, instead of marking the temperature difference between the two solid contact surfaces of the rock and velvet which they touched, the points of the thermo-electric forceps showed the temperature of the fluid air-bath in which those two surfaces are immersed. The extreme mobility of this integument, enabling it to penetrate through the velvet to the plates of the heater and the cooler, while it equally insinuates itself between the rock surface and the thermopile that can only enter into actual solid contact with each other (at least theoretically) at three points, controls the temperature of the metallic thermometer far more powerfully than the rock face that it touches, and the real temperature differences between the rock faces are accordingly completely masked. It is very probable that if the velvet covers fitted on the instrument were replaced by soft wash-leather, the source of this error would be very much reduced; and although it is certain that the confronting surfaces of the rock and leather faces will nowhere have actually the same temperature, from the existence of a sensible quantity of resisting air between them, so that, as before, the thermopile will not mark the true rock temperature difference, but a mean between that difference and a similar difference for the leather faces, yet the range of this error will be incomparably smaller than in the experiments already made with velvet covers, whose loose texture precludes the possibility of regarding the comparative results now obtained as positively correct, or more than first approximations, from which the errors arising from surface characters of the rock sections tested have not yet been removed.

To obtain the true rock temperature differences, means were taken to cement the thermopile points to the rock with plaster, a course it would be desirable to adopt with as few samples as possible as standards of correction for the rest, on account of the tediousness of the process and the injury that it necessarily entails to the beautifully worked surfaces of many of the plates. If the correction so found to be required can be restricted by the mode of operating to a range of such small limits as to be applicable generally, without appreciable influence of the surface characters, in making its occasional departures from a mean value very sensible, then the reduction factor found by absolute experiments on a few rocks of characteristically rough and smooth or polished surfaces to obtain the true temperature difference for a given heat-flow from the apparent one shown by the thermocouple placed simply between the rock and leather faces will be admissible within the limits of error of the observations to convert a list of apparent conductivities as just supposed to be ob-

tained from a mere comparative table of relative conducting powers to a table of absolute thermal conductivities, in which the errors of the values given will certainly not be greater than would in all probability have been committed had the direct method of absolute measurement been applied separately to each specimen of the list, instead of only to a few rocks, to furnish data on which calculations of the remainder may be founded. Circular discs of linen, well wetted with plaster of Paris, mixed with a little glue or white of egg, were laid over the surfaces of two or three of the rocks, enclosing under them and against the rock (to which they were also plaster-wetted) the two branches of the thermopile pincette. When these had set quite hard under pressure and were thoroughly dried by a gentle heat, they were placed in the apparatus, and a measurement of the absolute temperature difference and accompanying heat-flow was thus obtained, affording the real conductivity and a means of comparing it with the apparent one found by similar observations of the same rock when no plaster was used, and when the points of the thermopile merely pressed against its surface. Thus the thermo-electric difference obtained with the wire couples merely touching the surfaces of white statuary marble between velvet faces was 16°, while for the same heat-flow, when the arms of the thermopile were firmly plastered to the marble plate, the temperature difference observed was only 16°·2,[1] being more than $2\frac{1}{2}$ times as large a difference in the former as in the latter case. With whinstone the corresponding temperature differences were 26° and 8°·5, in the proportion of very nearly 3 : 1. A similar experiment was made with cannel coal, of which the conductivity is much less than that of the last-mentioned rocks, the temperature differences obtained being for the same heat-flow in the plain and plastered plate 53°·4 and 39°·7; in the proportion of only 1·37 : 1, a far smaller reduction than was observed in the two foregoing cases. Care is, however, necessary to introduce wet plaster under as well as over the points of the thermopile in cementing them to the rock, that air may be excluded and the junction may be solid, a precaution which was omitted in this case, as plaster without size was used, which in drying sometimes flakes off from the rock surface either entirely or in places. This may render an experiment, as that on cannel coal may not impossibly have been, from this cause entirely valueless; yet this result presents itself, with many others met with in the investigation, as very well worth repetition, with fresh precautions and with new arrangements to guard against the possibility of false conclusions.

Adopting for the present, as probably not very far from the truth, a common reduction factor of $2\frac{1}{3}$ as the proportion in which the recorded temperature differences of the plain rock surfaces between velvet faces exceeded the true temperature differences of the surfaces of the rocks examined, and introducing some very small corrections for the thicknesses of the plates, the thermal capacity of the metal cooler, &c., which are all probably (as well as the allowance for heat-absorption in raising the temperature of the rock plates very slowly during the observations) really negligible in comparison with the uncertainty that attaches (except in one or two well-observed cases of absolutely measured temperature differences of the rock faces) to the great majority of the determinations from unknown peculiarities of surface contact and temperature assimilation where air is not excluded from the junctions, or rendered stagnant in its mode of heat transmission, the following table gives the absolute thermal conductivities (in centimetre-gramme-second, or absolute British Association units) thus provisionally obtained, together with a few similar results found by Peclet, Forbes, and Sir William Thomson in rocks differing little in their description from those included in the present list.[2]

H. Negretti exhibited Negretti and Zambra's new Recording Thermometer. It differs from others in the following important particulars :—1. The thermometer contains only mercury, without any admixture of alcohol or other fluid. 2. It has no indices or springs, and its indications are by the column of mercury. 3. It can be carried in any position, and cannot possibly be put out of order, except by actual breakage of the instrument. And, lastly, it will indicate and record the exact temperature at any depth of the sea, irrespective of either warm or cold current or stratum through which the thermometer may have to pass in its descent or ascent. This new recording thermometer, in connection with a simple clock, will also give the exact temperature of the air at any hour of the day or night, a most important addition to our meteorological instruments, and no slight boon to observers in many parts of the world who are engaged in taking simultaneous observations with our own at fixed hours.

G. J. Symons exhibited a series of fourteen very carefully-made thermometers, all differing either in the size or shape of the bulbs, or in the materials with which they were filled, some being mercurial and some alcohol. They had been specially constructed with a view to testing the relative sensitiveness of different patterns and sizes. The results of the experiments had been printed in the "Quarterly Journal of the Meteorological Society," and were briefly the following :—That very large spherical mercurial bulbs are very little better than those filled with alcohol, but that with small bulbs mercury is much the most sensitive. The new minimum thermometers (the bifurcated and the double cylinder) introduced respectively by Casella and Hicks, were highly praised. Mr. Symons said that he brought them before the section mainly in order to offer the loan of the entire series to any experimentalist with more leisure than himself, who would develop and complete the inquiry which he had begun.

Professor J. D. Everett read the report of the Committee on Underground Temperatures. The work of the committee is the collection of observations bearing on the rate at which the temperature of the ground increases with depth. Observations have been received during the past year from the following places :—Great well at La Chapelle, Paris, which is 660 metres deep in its present stage; a mine 1,900 ft. deep at Pzibram in Bohemia; the Australian goldfields; two of the mines of the Société Cockerill, at Seraing, in Belgium. The observations show that there is considerable difference in the temperature at the same depth in the several places.

Captain Abney, R.E., gave an account of the means adopted for ensuring at the different stations which would be occupied by the parties sent out to observe the transit of Venus, photographic observations of the phenomenon in question. It had been determined that at every station a photograph should be taken every two minutes during the transit, and it has been a matter of considerable labour to work out a process that would admit of such a large number of negatives being taken in a hot

[2] *Provisional Determinations of Thermal Conductivities of certain Rocks.—First Experimental Results.*

Description of Rock.	Thermal conductivity (gramme-water-degree heat units per second) at 1° difference of the faces, through a centimetre tube.	Earlier Observations of Conductivities of similar Rock.		
		Description of Rock.	Observers.	
Grey Aberdeen granite	·00600			
Red Cornish serpentine	·00483			
Calton trap rock (first specimen)	·00520	·00566	Calton trap rock	Forbes and Thomson.
Whinstone	·00312	·00169	Sand of experimental rock, Thermometer garden	
Kenton sandstone	·00489	·00685	Craigleith sandstone	
Congleton "second grit" stone	·00462			
Slate	·00392			
Alabaster	·00412			
Sicilian white statuary marble	·00559	·0097	Fine-grained grey marble	Peclet.
Irish fossil ditto	·00559	·0077	Coarse crystalline white ditto	
Devonshire red ditto	·00525	·0058	Fine-grained calcareous stone.	
Italian vein marble	·00512	·0047	" "	
Irish green marble	·00597			
Nummulitic limestone (a piece of Great Pyramid casing-stone)	·00433	·0037 ·0035	Coarse-grained lias building stone	Peclet.
Caen (building) limestone	·00395			
Chalk	·00384			
Black shale (Newcastle-on-Tyne)	·00178			
Cannel coal	·00161			
Plaster of Paris (for castings)	·00163	·00145 ·00122	Ordinary fine plaster (made up) Finest ditto for casting (made up)	Peclet.

[1] The heat-flow through the plate was actually greater in this latter than in the former case in the proportion of about 5 : 4, showing that the rough plaster-washed linen surface received and delivered heat to the velvet covers much more readily than the smoothly-dressed surface of the stone, and the whole resistance was less in the latter than in the former case, although the rock plate itself had been made thicker. The same diminution of the total resistance occurred also in the experiment with plastered whinstone.

climate. In Kerguelen's Land it would be perfectly feasible to adopt the ordinary wet process, the low temperature admitting of it, but in a temperature of 90° F. the evaporation of the volatile constituents of the collodion would render such a process inapplicable, as all photographers would admit. In India, where the author had worked, a large-sized tent had often proved injurious, and it would have been madness to have trusted to the wet method. It was therefore determined to use a dry process if practicable, and after much deliberation it was decided to employ an albumen dry process, using a highly-iodized collodion and strong alkaline development. The author gave an account of the advantages thus secured, and discussed how each could be best obtained, especially alluding to the phenomenon of irradiation. He mentioned that at each station the photographic party would consist of one officer and three sappers all well trained to the process, so that all excitement at the critical moment might be avoided. Practice on a mock transit that had been equipped at Greenwich has given them thorough knowledge of each phase of the phenomenon.

Of the papers in the Mechanical Section, that by T.R. Salmond, C.E., on the Belfast Harbour, was perhaps the most interesting. We take the following from the "Belfast News Letter:"—It is with no small degree of diffidence that I have, on request, undertaken to contribute a paper on the Port and Harbour of Belfast; the subject being one of considerable importance, and the materials at my disposal somewhat meagre, at least so far as the ancient history of the harbour is concerned. I have, however, endeavoured to prepare in as concise a manner as possible a synopsis of the various improvements which have been effected in the harbour—at least, so far back as the sixteenth century; prior to which time the position of Belfast as a seaport or place of resort for shipping was rather vague and indefinite, if we can judge from the fact that no mention whatever is made of its existence as a harbour in any historical record prior to that date. On examination of the map of Belfast, which was prepared as early as 1660—perhaps one of the most ancient maps of the town now extant—it will be seen that the old town was, as compared with Belfast of the present, a very insignificant place indeed. The limits of the town were circumscribed by an extensive line of fortification, which encompassed it on the north, south, and western sides only, it being bounded on the east side by the river Lagan, the land entrances to the town being by two gates, called the North Gate and the Mill Gate. The North Gate was situated in North Street, at its juncture with John Street, and the Mill Gate was situated in Mill Street, at a point about 330 yards from the entrance to the Old Castle. It would then appear that the ramparts of the town ceased at William Street, and commenced at Mary Street, now called Corporation Street; the interval between these points being bounded by the Lagan river precluded the chance of land attack from the eastward side of the town. At this time Belfast only consisted of five streets—High Street, Bridge Street, Skipper's Lane, Waring Street, and North Street—and the number of houses then in existence were, exclusive of the castle, 150, the greater number of which were thatched houses of an inferior class.

Previous to the year 1637 the harbour appears to have been under no regular system of government, and was assumed to be the property of the Chichester family. The trade was at that time as insignificant as the harbour itself, which was in point of fact a port of secondary importance to Carrickfergus, which was the only stronghold in the bay, occupying the same position relative to the latter town that Carlingford did in respect to Newry. Prior to the date I have just mentioned the corporation of Carrickfergus enjoyed the privilege of reserving to their use one-third of all the Customs duties payable on goods imported into that place, together with other trading monopolies. These immunities, however, the Earl of Strafford succeeded in purchasing in 1637, since which time the commerce of this port has become a matter of importance. A custom house was then for the first time established in Belfast, and the revenue business of the port removed from Carrickfergus. In the year 1729 the first legislative interference with the port took place, when an Act (3rd George II.) was passed, which delegated to the sovereign and free burgesses of the town the conservancy of the harbour. The corporation of Belfast had the harbour trust committed to their care, and the reason assigned for appointing them as the conservancy was, that as expressed in the Act, "the harbour had become extremely shallow, by which means voyages have been prolonged, to the very great prejudice of trade, and his majesty put to extraordinary expense and charge in keeping officers longer on board the vessels trading to and from the said town than would be needful had the said harbour and channel been preserved in the same condition as it formerly was." This Act was, however, repealed in 1785 by the Act 25th George III., cap. 64, which appointed a separate corporation, giving to them the sole management of the affairs of the port; and with the appointment of the Harbour Commissioners as a distinct body the substantial improvements of the port may be said to have commenced.

Among the first acts performed by the new corporation were the removal of several artificial fords, which formed bars across the Lagan, and also the gradual deepening of the bed of the river by dredging; and in 1786 the course of the old south channel was ordered to be marked with buoys and perches down to the Pool of Garmoyle.

In the year 1791 a graving platform was erected for the repairing of small craft; and, subsequently, two graving or dry docks, which are at present in existence, were constructed, the first of which (No. 1) was completed and opened in the year 1800, and the second, now called No. 2 Dock, was opened in the year 1826.

These docks are situated on the south-west side of Clarendon Dock, and are found to be of great service for the repairing of vessels of small draught and tonnage. Their general dimensions are as follows:—

DOCK NO. 1.

	Ft.	In.
Length on floor	245	0
Do. at top	252	6
Breadth at top	50	0
Do. at bottom	35	6
Level of sill above datum	1	9
Depth of dock from coping to floor	14	0

DOCK NO. 2.

Length on floor	287	0
Do. at top	299	0
Breadth at top	58	0
Do. at bottom	34	0
Level of sill	datum	
Depth of dock	15	6

In the year 1826 Mr. John Rennie reported upon the state of the harbour with a view to its being extended and improved, and, in the year 1829, Mr. Telford reported for a similar purpose. Mr. Rennie again reported in 1829. No action, however, was taken on either of these reports, and the improvement of the harbour was consequently delayed until a report and plan had been received from Messrs. Walker and Burgess, in the year 1830, which plan was adopted by the commissioners, and received the royal assent in the year 1831. Obstacles were, however, thrown in the way of procuring the necessary funds to carry out the work, and the result was an application to Parliament, in the year 1837, for a new Act—1st Vic., cap. 76—which was acceded to, and the works directed to be undertaken in connection therewith were:—

1st. The making of a new channel for the river Lagan, from Dunbar's Dock to Thompson's Tower, cutting off the first bend of the old channel nearest the town.

2nd. The purchase of the existing quays and docks, which were private property, and the widening and improving of the same.

3rd. The continuation of the straight cut for the river, as far as deep water, cutting off the second bend of the river, so as to form a straight channel from the town towards Garmoyle; and other works contemplated by the Act.

The first of the foregoing works, being the first section of the new channel, was undertaken by Mr. Dargan, the contractor, and was completed and opened in the year 1841, the cutting of the channel forming a very valuable property called the Queen's Island, which contained an area of seventeen acres of land. The entire cost of this work, including the purchase of property, amounted to £42,352.

In the year 1842 the old quays and wharves on both sides of the river, together with Dunbar's Dock (now called Prince's Dock), quays, timber pond, and nineteen acres of ground, the site for future docks, were all purchased at a sum amounting to £152,171, and a sum of nearly £1,000 was expended in the improvement and permanent repair of Prince's Dock, the walls of which were composed of timber and brickwork.

In the year 1844 the construction of new quays was commenced on the County Down side of the harbour for a length of 2,500 ft.—about 500 ft., next the Queen's Bridge, being in front of an old wharf purchased from Mr. Batt, and the remaining portion on the slob land lying between it and the Queen's Island. This work was called the Queen's Quay, in the construction of which was expended the sum of £31,167. It is composed of a facing of timber securely tied back by three rows of strong piles, which are connected together with tie rods of iron $1\frac{1}{2}$ in. in diameter; the main piles are 12 in. × 12 in., and the sheeting piles are 7 in. in thickness, driven to a batter of 1 in. to a foot. The quay being formed, a landing shed was erected on it, 300 ft. in

length, at a cost of £2,186, which is included in the cost of the quay. The material used for filling in or backing up the quay was mainly procured by the deepening of the river, which was also considerably widened in front—a quantity, amounting to about 524,175 tons, of material being deposited in forming the quays.

Among other works carried out at this time were a large pond for the storage of timber on the east side of the Queen's Island, formed at a cost of £1,878; and the lighthouse, erected on piles, which is situated on the Holywood Bank, and which is used as a pilot station, which was constructed at a cost of £1300.

Having, in the year 1844, secured possession of the old quays and other property on the County Antrim side of the river, the construction of new quays on that side was immediately proceeded with. The total length of quayage erected at that time was 1,375 ft., of which 713 ft. was an increase, the remainder being the restoration of a portion of the old work. These quays were formed of timber, and were carried out on the same plan as that adopted for the Queen's Quay.

The total monies expended previously to the year 1847 on the various works embraced in the Act of 1837, including the construction of the Holywood Bank Light Station, amounted to £238,740.

In November, 1846, a contract was entered into with Mr. William Dargan for forming the second section of the new channel. Very little, however, was done towards the execution of the permanent portion of this work until the close of the year 1847, the interval being mainly occupied in preparing for keeping the works clear of water, the difficulties experienced in doing which having retarded the commencement of the cut itself, until, in fact, half the time within which it was to have been completed had expired. It was, however, finally completed and formally opened in the year 1849, when it received the title of Victoria Channel. This, the second portion of the channel executed, lies between the Twin Islands, which were formed by the material excavated from the bed of the second cut, and cast up so as to form a sea slope of about 4 ft. horizontal to 1 ft. vertical, the channel faces of which slope were protected by a heavy facing of stone pitching laid by hand. The length of this cut is about 3,300 ft., the width at top being about 450 ft., with a depth of about 23 ft. at high water, and the amount expended in its formation was £41,000.

The next work of importance which was proceeded with was the rebuilding of the County Antrim quays from the Queen's Bridge to Dunbar's or Prince's Dock, and their extension, or the formation of new quays, from that point to the Milewater River, the latter portion being commenced and completed in the year 1847, the entire quays being handed over by the contractor, Mr. Cranston Gregg, complete, during the year 1848, their cost being about £44,390. This work is composed of timber facing similar to that adopted on the Queen's Quay, and the entire designed with a view to having about 10 ft. of water close to the quay at low tide.

In the year 1847 the construction of a patent slip was commenced on the south end of the Queen's Island. This slip is 560 ft. in length, and was designed so as to be capable of taking on vessels of 1,000 tons burthen. It is worked by a 20-horse power steam-engine, with hauling machinery. The cost of the entire work in connection with the slip was about £16,753. Of this, the cost of the machinery and buildings amounted to £4,766; the foundations for the work, in consequence of the very bad nature of the soil on which it was erected, costing more than double that of the machinery and buildings. The work was completed and opened for traffic early in 1849. In the year 1847, owing to improvements then in contemplation, and in course of progress, it became necessary to procure a new steam-dredger in addition to the one then in the commissioners' possession. The new machine was constructed in that year by Messrs. Coates and Young, and was provided with a 20-horse power engine and machinery, and a much larger bucket-frame than the old dredger. The cost of the new machine was £5,260. The way in which the dredgers were principally employed at this time was in deepening of the river between the new wharves, and the material raised was used for filling up the spaces between the old and new Ballymacarrett quays, filling up the old town dock at the foot of High Street, and other old docks on the County Antrim side of the harbour, and in backing up the new quay of the first cut of the channel, now called Albert Quay.

In the year 1847 a second timber pond was constructed on the County Antrim side of the river, and is situated convenient to Prince's Dock and Albert Quay. This pond was made by Mr. Dargan in a field adjoining the old pond, about 20,000 cubic yards of stuff being removed in its formation.

The only additional works worthy of notice which were undertaken in the year 1848 were the erection of a stone beacon on the tail of the west bank at Garmoyle, at a cost of £218, and the construction of a wrought-iron swing-bridge, to span the entrance to the then Graving Dock Basin, at a cost of about £1,351. These works were completed during the year 1849.

In the year 1849, in order to meet the growing requirements of a very important class of shipping, such as the moderate-sized vessels carrying valuable cargoes from the Mediterranean and Baltic ports, it was determined to extend the basin in front of the Graving Docks. This work was proceeded with, the basin being extended in a southward direction, so as to form a dock, which, in 1850, was designated the Clarendon Dock. In the same year, 1849, the old tidal docks, situated at the foot of Waring Street and Great George's Street, were filled up, and the spaces occupied by them thrown open to the public.

Prior to the commencement of the improvements embraced in the Act of 1837, the cost of dredging had always formed a large item in the annual expenditure of the Belfast Harbour. This had, however, considerably increased during the four or five years just preceding the year 1849; as, in addition to maintaining the original depth, the course of the river opposite what was then called Ritchie's Dock was diverted from its natural channel by the extension of the quays, and the entire space from the Queen's Bridge to the Prince's Dock doubled in width, the depth of the water being at the same time increased 5 ft. to 7 ft.

It was anticipated that the formation of the straight channel would obviate the necessity of so much dredging as hitherto in the lower part of the river, and the fact that the upper section of it maintained its depth without dredging from its opening in 1841 for a period of nine or ten years, confirms this view. The increased depth, however, given to the river opposite the quays, being much below its natural bed, will always require an additional amount of dredging to prevent it from silting up, which would, of course, vary and increase in extent as the sewerage of the town increases, if allowed to be discharged into the harbour.

In the year 1850 the only works worthy of notice which were entered upon were the erection of coal offices, yards, and weighing machines on Queen's Quay, and six landing or goods sheds on Donegall Quay, and contracts for the erection of a stone retaining wall on the north side of the Clarendon Dock.

In the year 1851 three lighthouses were constructed in the Channel between Garmoyle and the town of Belfast, and provided with accommodation for resident lightkeepers in order to supersede the difficult and uncertain plan previously resorted to —*i. e.*, of attending to the Channel lights (which were fixed upon perches) by means of a boat. One of the houses, a substantial stone structure, is situated on the lower end of the East Twin Island, and provided with a bright green light; one on the margin of the old Seal Channel, provided with a red light; and the other at the Pool of Garmoyle below the stone beacon, and on the opposite side of the Channel, which is provided with a green light. The two latter lighthouses are constructed on the borders of the slob banks, and are composed of timber supported upon strong piles of the same material braced with wrought-iron tie rods, the cost of the three houses being about £741.

In the year 1852 a metal foot bridge was constructed across the entrance to the Prince's Dock at a cost of £309, and a timber bridge across the entrance to the Milewater river at a cost of £39, thereby opening up an uninterrupted traffic for foot passengers from the Queen's Bridge to Thompson's embankment.

In the year 1854 a new, handsome, and commodious Harbour Office was erected at the foot of Great George's Street, at a cost of £8,306, and the only other new works carried on in that year were the construction of a branch line of railway, commencing at the main line, a short distance from the terminus of the Northern Counties Railway, running along the reclaimed ground purchased from Mr. Thompson, and connected with the Albert Quay; and a new street called Whitla Street, running from the north end of Garmoyle Street to York Street, opening up a connection between the quays and the railway.

The Harbour Commissioners having, in the year 1854, obtained a Bill empowering them to reclaim a large portion of the slob lands lying on the County Down side of the river, consequently in the following year a commencement was made upon that work, Mr. James Connor being appointed contractor for the execution of a bank extending from the Queen's Island to Conswater railway bridge. This work was completed in 1858. This portion of the reclamation included the part to be devoted to the purposes of a public park, to be called Victoria Park.

In the year 1858, a commencement was made towards the regular deepening of the navigable channel from the Holywood Lighthouse to the upper end of Donegall Quay for a width of about 100 ft. The improvement made by the dredging opposite the lighthouse was such that vessels with a deep draught

of water were enabled to get up to the lower end of the Victoria Channel without lightening their cargoes, as they had hitherto done, two miles lower down the river, in order to enable them to take a berth at the quays, or to enter the docks; and steamboats were also enabled to reach their berths at all times of the tide. Dredging continued from the year 1858 to 1861, and an average depth of 11 ft. at low water was secured between Holywood bank and the town. The next works of magnitude which were undertaken by the Belfast Harbour Commissioners were commenced in the year 1864, and consisted of the construction of a large floating dock and tidal dock on the County Antrim side of the harbour, and a large graving or dry dock and tidal basin on the County Down side of the harbour. These may be said to be the first really important works, apart from the deepening of the harbour, which were undertaken since the year 1847.

Unlike the previous mode of constructing the wharves with timber, the commissioners were advised in these cases to resort to the use of stone as a building material. On the County Antrim side of the harbour, where the ground for foundations is of such a treacherous nature, the entire works had to be built upon bearing or supporting piles. These piles were of round larch timber, 15 ft. in length, and 10 in. diameter at the top, tapering to 7 in. at the bottom. On the top of the piles a layer of concrete 2 ft. in depth was laid, on which the superstructure was raised. The walls are generally of the section shown on the contract drawing, and are built of rubble stonework, faced with a description of masonry known as granite rubble, and peculiar to the Liverpool Dock works. The coping of the walls is 16 ft. above datum, and the depth of water provided for opposite the walls is 15 ft. below datum. On the County Down side of the river, the nature of the soil is so good as to require no artificial foundation, being firm, hard sand. On both sides, however, the precaution has been adopted of driving a row of short piles, 6 in. thick, along the face of the work, to preclude the chance of the foundations being undermined by dredging or other causes.

These dock works, though commenced in the year 1864, were not all completed till the year 1871. The Hamilton Graving Dock and Abercorn Basin were, however, finished and formally opened by the Lord Lieutenant in the year 1867.

The Abercorn Basin is 725 ft. in length by 635 ft. in breadth, having a water area of 12½ acres, and about 1,370 lineal feet of quayage. The average depth of water in that basin is now about 11 ft. at low water.

The Hamilton Graving Dock is in length at top 470 ft., and at bottom 451½ ft. It is 84 ft. 6 in. broad at coping, and 50 ft. broad at bottom. The coping is 15 ft. above datum, and the level of sill at entrance is 560 ft. below datum. The entrance of the dock is 60 ft. in width, and the depth of the dock is 22 ft. 9 in. below coping. It is provided with a caisson gate, which can be used as a bridge or road for horse and cart traffic when set in place. A powerful engine and centrifugal pump, with pumping machinery, is provided for clearing the dock of water when requisite for repairing vessels. The cost of the Abercorn Basin, including mooring-buoys, chains and screws, lamps, pawls, protecting chains, paving of quays, &c., amounted to £23,163. The cost of Hamilton Graving Dock, including mooring-pawls, paving, cloughs, gas and water-pipes, sewerage, paling-plank, stones, capstans, lamps, &c., amounted to £33,756. Of this, £2,376 was expended on the caisson, and a further sum of £5,140, not included in the above, was expended on the engine and pumping machinery and buildings in connection therewith.

The works on the County Antrim side, comprising the Spencer Dock, Dufferin Dock, and entrance basin, were formally opened by Earl Spencer, Lord Lieutenant of Ireland, in the year 1872. The Spencer Dock is a tidal dock, 600 ft. long by 550 ft. broad, having a water area of 7½ acres and a quayage in length 1,900 ft. and area of 9 acres. The average depth of water in this dock is 14 ft. below datum, and the coping is 15·6 ft. above datum. The entrance to the dock is 80 ft. in width by 265 ft. in length. The entrance basin has an area of 5 acres of water, with a quayage of 200 ft. in length.

The Dufferin Dock is a floating-dock, provided with gates, inside which vessels with a draught of 22 ft. can discharge afloat at all times of the tide. The entrance to this dock is from the Spencer Dock, and is 60 ft. in width by 139 ft. in length. The platform for gates is 14 ft. below datum, and the sill is 12 ft. below datum. The dock is in length 630 ft. by 225 ft. in width, having a water area of 3¼ acres and length of quayage of 1,645 ft., the area of same being 7½ acres. The average depth of water in this dock is 23 ft., the coping being 16 ft. above datum and the depth of the dock below datum 14 ft.

The walls of these works are all constructed of stone, the lower portion of the dock from bottom up to datum level being composed of hammerstone ashlar, the stone being from the Scrabo quarries, County Down, and the portion above datum is composed of freestone hearting, with facing of Dundonald whinstone, the coping being of Cornish limestone in large blocks. The cost of these works amounted to £95,334, including gates, mooring buoys, chains, pawls, lamps, water and gas, sewerage, paving, &c. Simultaneously with the execution of these works other incidental works, though of minor importance, were being carried on. The Milewater River was diverted into a new channel, and two extensive timber ponds, one of 5 acres and the other of 14 acres, formed on the Antrim side of the harbour, chiefly by the excavations from the dock works. The branch railway was diverted along Albert Quay, and a permanent line of tramway laid connecting it with the Northern Counties Railway.

The slob reclamation in County Down was being proceeded with from year to year, and in 1864 a carriage road bridge was constructed across Connswater to connect the Victoria Park with the Ballymacarrett reclaimed property, at a cost of £652.

In 1867 a double line of tramway was laid along the south side of the Abercorn Basin, and connected with the County Down Railway. A number of goods sheds were erected along the quays from time to time, and dock-masters' and other tenements, as required by the extension of the harbour; and in the year 1871 a large pair of masting sheers were erected on the east side of Abercorn Quay, capable of lifting a weight of 50 tons, and masting the largest vessels afloat; the cost of these sheers amounted to £2,732, including foundations, engine-house, &c. In the same year (1871) a line of tramway commencing at the junction of the Central Railway at Oxford Street and extending along the Antrim quays around Prince's Dock, formed a junction with the branch of Northern Counties quay's tramway at the south end of the Dufferin Dock. Two twenty-ton weighbridges, capable of weighing either waggons, carts, or lorries, have also been constructed in connection with the tramway. Owing to the extension of the harbour works, it became necessary in the year 1870 to provide for extensive dredging. A contract was therefore entered into for a new steam dredger, of 40 horse-power, capable of working in 26 ft. of water, which was completed in the following year, at a cost of £7,923, and a large number of new scows were constructed in connection with this machine. In the year 1872 an inclined discharging slip was constructed at the lower end of the Queen's Island, and provided with a hauling engine and gearing for the purpose of disposing of the dredging material in the embanking of the County Down reclaimed lands; and for the transit of the stuff a locomotive and stock of tipping waggons were provided, by which means the material can be both cheaply and expeditiously transported to any part of the County Down property. In the same year, the commissioners having secured by purchase from Dr. Ritchie a large tract of slob land on the Co. Antrim side of the channel north of Thompson's embankment, a commencement was made with its reclamation from the sea. This work is still in course of progress, and when reclaimed will afford a valuable parcel of ground for harbour extension, 95 acres in area. The embankment is being entirely formed of material raised by the dredgers in deepening the harbour. The slope is formed on the outside, at an inclination of 4 to 1, and is being securely protected by stone-pitching, hand laid. Having acquired the latter grounds, steps were at once taken to form a large portion of it into a timber pond, which was done by enclosing an area of about 26 acres with a row of closely-driven round larch piles.

In the year 1872, a work of considerable magnitude was commenced, and is at the present time in course of progress; it consists of the renewal of the entire length of Albert Quay, and its further extension to the circular pier-head of the Spencer Dock. A portion of this work for a length of 267 ft. is constructed of stone, in the same manner as that in which the other stonework of the docks is executed, the remainder being constructed of timber. The entire length of the work is about 60 yards, which will give, besides the renewal of the decayed portion of the Albert Quay, an additional length of quayage of 207 yards. The timber wharf is about 1,776 ft. in length by 25 ft. in width at the top; is composed of three rows of bearing piles of pitch-pine timber, 12 in. square, the front row being 48 ft. in length, the middle row 43 ft., and the back row 39 ft. These piles are driven 5 ft. apart, centres longitudinally, and between each two piles in the front and mid row, sheeting piles of the same timber, 11 in. in thickness, are driven quite close together, the length of the front row being 37 ft., and that of the middle row 32 ft. The front and back rows of main piles are secured together by diagonal braces of timber 12 in. by 6 in., crossing and bolted to the middle row of piles. The platform is composed of strong joists 12 in. by 6 in., sheeted with timber planking 6 in. thick, which is covered with a layer of bitumen, and finally paved with square-setts on a

bed of sand, and grouted with hydraulic mortar. The back of the wharf is sheeted with timber 4 in. in thickness, against which is filled a backing of engine ashes and cinders, in order to secure the least possible lateral thrust against the wharf. The space underneath the wharf, between the front and back row of piles, is formed into a slight slope, which is paved with pitching stones, in order to prevent the abrasion of the water from carrying away the soil; and the front face of the wharf is *cleaded* with open timber work, to prevent the deposit and accumulation on the slopes of bulky matters held in suspension by the water. Mooring piles of greenheart timber, cupped with cast-iron hoods, are driven every 60 ft. apart along the entire wharf to secure vessels to; and a number of sets of strong piles 26 ft. long are driven 60 ft. back from the wharf, and are connected with it by substantial tie-rods of wrought iron, in order to guard against the possibility of the wharf being driven forward by any undue weight placed on the platform, or by the weight of the materials by which it is backed up. The piling of this work is so designed that a depth of 16 ft., at low water, may be secured by dredging, without the risk of injuring the stability of the superstructure, and by the setting back of the quay-line as it is done a water space of about 335 ft. in width will be provided in the river opposite the new wharf. This work is being carried on by Messrs. H. & J. Martin, contractors, and will, when completed, cost about £50,000. During the present year, an extensive double line of tramway has been laid by the Harbour Commissioners, from the south quay of the Abercorn basin through their property in Ballymacarrett, and connected with the Central Railway near the point where it crosses the County Down line. This tramway completes a system which opens up a thorough line of communication between the County Antrim and County Down sides of the river, and affords a valuable means of transit of goods by rail from almost all quays in the harbour to the County Down, Central, Ulster, and Northern Counties railways. In order to meet the rapidly-increasing requirements of the trade of Belfast for additional dock and harbour accommodation, I lately received instructions from the commissioners to prepare plans and specifications for works of considerable magnitude proposed to be carried out on the County Antrim side of the harbour. The plans which I submitted were approved of, and are now before you. They consist of a large wet dock 1,200 ft. in length, exclusive of the entrance, and 280 ft. in width, with a depth of 20 ft. at low water. This dock it is proposed to extend when the trade of the port shall have increased to such an extent as to warrant it, from where it is at present shown to terminate, to the foot of Corporation Square, an additional distance of about 1,250 ft., which would close the Clarendon Dock, and do away with the two old graving-docks situate off that dock. The entire length of the dock when completed would be 2,450 ft., giving a water area of about 15¾ acres, with two entrances, one where the present entrance to Prince's Dock is situated, and one entering from the Spencer Dock; and I may just state that my reasons for recommending an open wet dock in preference to a dock closed by gates, are that the moderate range of tide which exists in this harbour being only 8 ft. average, together with the improved modern mechanical appliances for loading and discharging vessels, renders the rise and fall of a few feet of tide an immaterial question either as regards time or money; and further, that with an open dock vessels will not require, as they would with a close dock, to accumulate opposite the entrance to such an extent as to impede the general traffic in the outer or Spencer dock, a free and open means of communication being maintained with the river, so that vessels can arrive and depart at all times of the tide. The gates and sluices of a close dock are also liable to derangement or accident, and tend under any circumstances more or less to limit the amount of traffic to the dock.

It is also proposed, in order to meet the demand for additional graving dock accommodation, to construct, on the County Antrim side of the river, a dock of about 600 ft. in length, capable of receiving the largest vessels built in or frequenting this port.

Another extensive improvement, which has for some time occupied the attention of the commissioners, is the formation of a new straight channel across the West Bank, in continuation of the Victoria Channel, between the Twin Islands and Whitehouse Roads; this will, no doubt, when carried out, afford great facilities (as compared with the present circuitory route) for vessels either entering or leaving the port, and lessen the risk of danger and delay consequent upon vessels taking the ground on the slob banks lying on either side of the present channel. I have thought it might be interesting, and have therefore appended to my paper detailed information as to the areas, &c., of the property at present in possession of the Belfast Harbour Commissioners. The total area of property on both sides of the harbour is 924a. 2r. 22p., of which 526a. 1r. 11p. is on the County Antrim side and 398a. 1r. 11p. on the County Down side, 95 acres of the property on the County Antrim side being at present in course of reclamation. Of the above area about 398a. 1r. 11p. has been reclaimed from the sea. The total water area of the harbour, including docks and basins, amounts to 106a. or. 30p.; and the total length of available quayage 18,433 lin. feet. The area of timber ponds at present in existence is 64a. 2r. 20p.

Of the minor communications, one, on the prevention of railway accidents, by J. Smith, and another, on the measurement of ships by Captain B. Pim, should receive brief notice. The first paper stated that perfect safety might be relied on so long as the signals could be seen, and the engine-driver promptly and thoroughly respected them. Unfortunately these conditions were not at all times observed, and serious accidents frequently occurred, as would be found on reference to the Board of Trade reports made by Captain Tyler, and other Government inspectors from time to time. Whenever accidents did occur from the disregard of the engine-driver, or from his inability to see the signals, a conflict of evidence given at the coroner's inquest, or Government or other enquiry, was invariably the result. After many careful experiments he had succeeded in arranging a most complete and comprehensive apparatus which automatically recorded (1.) The directions given and received for regulating the movements of trains. (2.) The movement of every signal of every kind or description. (3.) The movements of the points and other portions of the road and way affecting the movement of trains or engines. (4.) The passing of trains in every direction, and (5.) The time and relation to such movements, &c., all upon the same roll or strip of paper in a succinct form. These results were obtained by connecting to the reciprocating parts of the point and signal working, or to the interlocking gear, a peculiar arrangement of electric contact making and breaking apparatus, acting through a simple electro-magnetic contrivance, which, in turn, operates on and deflects a pen, style, or worker which records upon the strip of paper the movement in question. In like manner the directions sent and received for regulating the traffic are recorded, as in the passing of trains, which are distinguished the one from the other. The whole of these movements are timed, and the time is recorded uniformly on one edge of the strip. Between the two records on the one edge of the roll or strip, and the passage of trains recorded on the opposite edge, the directions sent and received, signal movements, &c., are recorded between, and in a clear and intelligible manner; and in reference to these rolls all questions connected with the traffic working can be solved. The apparatus costs only a small sum, and the annual cost of maintaining and working it is also very small.

Captain Pim, after referring to the losses at sea arising from unseaworthy ships and unshipworthy seamen, pointed out how numerous and imperfect were our tonnage laws, and how futile had been the attempts to improve them. He advocated a new plan for measuring ships in view of impending fresh legislation on the subject. The true tonnage of a vessel was simply the number of tons of dead weight she was capable of carrying in safety, or her bulk between the light and load water lines. This principle had been well understood in former times, having been applied as long ago as 1694. His own method of measurement was to take the area in square feet of the horizontal plane at which the vessel floats when fully equipped with her masts and sails (or machinery and coals), and with her crew and provisions on board, and the area of the horizontal plane at one foot above it. Add the two areas together and divide by two, which will give the number of square feet, then divide by thirty-six for the tonnage, repeating the operation foot by foot between the light and load lines, leaving to the owner the responsibility of fixing the latter. The curves of one side only need be taken, and this could be done by a simple instrument, which any hedge carpenter could make and work. The sum of all the foot tonnages will be the entire tonnage, and whether the vessels be three-deckers or boats, wedge-like or circular, or as dissimilar as human ingenuity can construct them, the same rule will equally apply, and the same weight, when placed on board, will give the same increase of displacement to each.

We will conclude our sketch of some of the proceedings of the British Association, with a short note (taken from the "Ulster Examiner") on the works of the Ulster Peat Company at Cargan, to which place an excursion had been arranged. At these works peat is cut and dried in such manner as to render it more suitable for burning purposes. The peat is brought from the mountain side in lorries, and pulled on a tramway by means of machinery. There is a large upright cylinder which is continuously supplied with peat from a loft above, and while passing through this cylinder the peat is cut by revolving knives. The crushed or cut peat is from this forced into a horizontal cylinder of smaller dimensions, in which it is further masticated, the revolving knives not being at such a distance apart. The

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peat, which is by this time reduced to a soft, pulpy matter, is oozed out beneath through five apertures of about 5 in. square. It rests on a board, which is placed underneath to receive it, and then a boy cuts the full continuous streams, as they might be called, into lengths of about 15 in. each, when it is passed down along the shed on a tramway, and placed on sheds to dry. Some 80 tons of peat would thus be put in at the top in one day if the work was to continue uninterrupted; and it is curious, that out of those 80 tons will come about 15 tons of manufactured turf after it has been sufficiently dried. It is only about 1½ in. square after being dried, and it sometimes takes six and eight weeks before it is fit for use. This is, it appears, the only difficulty the company have to contend with. It is so difficult, particularly in the winter months, to get it properly dried, that it would require an immense number of sheds for storage during that time. For this reason the work has not been proceeding during the last month. The fire keeping the engine in motion is supplied by the peat which has been manufactured; and its qualities in this respect are equal to those of coals. At the works the peat is valued at about 9*s.* 6*d.* per ton, but it is believed it could not be supplied in Belfast at less than 15*s.*, which fact will, to some extent, account for coals being extensively used.

THE TRADE IN EXPLOSIVE SUBSTANCES.

NO one except those personally engaged in the matter—manufacturers, dealers, carriers, or users, as the case may be—can form any adequate conception of the large number of explosive substances now used in the arts. Chemistry, advancing by giant strides, is every year adding to the diversity of lovely colours, dyes, and pigments, evolved in many cases from the most unpromising substances; while in other directions the same science is teaching us to utilize the waste or refuse which unavoidably results from many manufacturing processes. In like manner, chemistry is rapidly adding to the number of known substances which possess extraordinary explosive powers, "good servants, but bad masters" (to use a homely saying)—substances as far exceeding gunpowder in bursting force as that exceeded all other explosives known before its invention. And in proportion as chemists discover these new compounds, so do practical men find the means of applying them, especially in mining, quarrying, excavating, tunneling, and various operations in military and civil engineering.

The systematic treatises on chemistry describe these explosives in the order of their chemical or atomic constitution, and devote more attention to their scientific relationship than to their practical uses. The engineer and the manufacturer naturally approach the subject from a different point of view, being interested, not in the atomic constitution, but in the explosive or blasting power of the several substances. It happens that there has recently been made public a very useful numeration and classification of such agents. To a committee of the House of Commons was entrusted the duty of "Inquiring into the law relating to the making, keeping, carriage, and importation of gunpowder, nitro-glycerine, ammunition, fireworks, and all substances of an explosive nature; and to consider the best means of making adequate provision for the safety of the public, and of the persons employed in such making, keeping, carriage, and importation, with a due regard to the necessities of the trade." There are many statutes in force relating to these matters, comprising the Gunpowder Acts, the Carriage of Dangerous Goods Act (1866), the Nitro-Glycerine Act (1869), and two local Acts relating to the storage of explosives in Liverpool and in the river Mersey. The public often complain that these results of legislation are not practically strong enough to protect life and limb; while dealers and carriers point out that trade is unnecessarily obstructed by some of the rules laid down. It was to investigate these divergent causes of discontent that the committee was appointed. The recommendations made by the committee we need not dwell upon here, as they cannot be clearly understood except by those who are practically concerned in the trade. The enumeration and classification of explosive substances, however, may fittingly be noticed, seeing that all who are interested in the subjects treated in the "Practical Magazine" may reasonably desire to know what new agents are placed at the disposal of miners, manufacturers, and technologists generally. The committee must have had the aid of a good scientific chemist in making out the list, for there is no member of the present House of Commons (with the probable exception of Dr. Lyon Playfair, who was not on the committee) up to the level of the subject.

The committee placed all the explosives which came under their notice in one or other of six classes or groups, as follows:—

1. *The Gunpowder Class*—viz.: any preparation formed by the mechanical mixture of a nitrate with any form of carbon, or with any carbonaceous substance not possessed of explosive properties, whether sulphur be or be not added to such preparation, and whether such preparation be or be not mechanically mixed with any other non-explosive substance. Many explosives having "gunpowder" as part of the name belong to another class, presently to be noticed; but those which conform to the above definition are four in number, viz.:—

Ordinary gunpowder,
Pyrolithe,
Poudrelithe,
Poudre-saxifragine.

2. *Nitro-explosive Class*—viz.: any chemical compound possessed of explosive properties, or capable of combining with metals to form an explosive compound, which is produced by the chemical action of nitric acid (whether mixed or not with sulphuric acid), or of a nitrate mixed with sulphuric acid, upon any carbonaceous substance, whether such compound is mechanically mixed with other substances or not. This class subdivides into two, viz.:—

a. Nitro-glycerine,
Dynamite,
Lithofracteur,
Dualine,
Gly-oxiline,
Nitrate of methyl,

and any other compound or preparation which consists wholly or in part of nitro-glycerine, or of some other liquid nitro-explosive; and

b. Gun-cotton,
Gun-paper,
Gun-sawdust,
Xyloidine,
Nitrated gun-cotton,
Cotton-gunpowder,
Schultze's powder,
Nitro-mannite,
Picrates,
Picric powder.

3. *Chlorate Explosive Class*—viz.: all preparations containing a chlorate mechanically mixed with any form of carbon or any carbonaceous substance, either with or without the addition of a nitrate, a sulphuret, or sulphur. Thus defined, the class comprises

a. Horsley's blasting powder,
Brain's blasting powder,

and any chlorate preparation which consists partly of nitro-glycerine or any liquid nitro-explosive; and

b. Horsley's original blasting powder,
Erhardt's powder,
German gunpowder,
Reveley's powder,
Hochstädter's blasting charges,
Reichen's blasting charges,
Teutonite,
Chlorated gun-cotton.

4. *Fulminate Explosive Class*—viz.: any chemical compound or mechanical mixture, which, from its great susceptibility to detonation, is suitable for employment in percussion caps, or any other appliances for developing detonation; or which, from its extreme sensibility to explosion, and from its great instability (that is to say, readiness to undergo decomposition from very slight exciting causes), is especially dangerous. There are two sub-divisions of this class. The first comprises

a. Fulminate of silver,
Fulminate of mercury,

and preparations of these substances, such as are used in percussion caps, together with any preparation consisting of a mixture of a chlorate with phosphorus or certain descriptions of phosphorus compound, with or without the addition of carbonaceous matter; and any preparation consisting of a mixture of a chlorate with sulphur, or with a sulphuret, with or without carbonaceous matter. The second comprises

b. Chloride of nitrogen,
Iodide of nitrogen,
Fulminating gold,
Fulminating silver,
Diazobenzol,
Nitrate of diazobenzol,

and compounds of analogous character.

5. *Ammunition Class*—viz.: any explosive of any of the foregoing classes when enclosed in a case or envelope, so as to form a cartridge for small arms or similar weapons; or to form any fuze for blasting or for shells; or to form any tube for firing cannon and mortars; or to form a percussion cap or a detonator. Thus defined, the class comprises two sub-classes:

a. Safety cartridges for small-arms,
Safety blasting fuzes,
Percussion caps,
Railway fog signals,
Safety fuzes for shells;

and the second sub-class,

b. Non-safety cartridges for small arms,
Detonators,
Non-safety blasting fuzes,
Non-safety fuzes for shells,
War-rockets,
Tubes for firing guns.

6. *Firework or Pyrotechnic Class.*—This, like most of the other classes, admits of sub-division:

a. Firework composition,
Any coloured fire composition.

The firework composition is defined to be any chemical compound or mechanical mixture of a combustible or inflammable nature, used for the purpose of making fireworks, and not included in any of the former classes of explosives.

b. Squibs,
Crackers,

and all other manufactured fireworks which have the explosive composition contained in a tube, or are otherwise in a finished state for firework display or pyrotechnic signals.

We have simplified a little the tautological style in which the several classes are described in the report of the committee—a style which seems to denote that, although a chemist has supplied the information, a lawyer has put it into the form so much adopted by his profession.

The recommendations of the committee, as we have said, need not be given here: nevertheless, it may be well to quote a few of the observations made.

Concerning gunpowder, "It appears, with regard to the situation of many of the large store magazines, that the safety of the public is not sufficiently provided for by adequate isolation of the magazines, with reference to the quantities they contain; and that the precautions taken by the storekeepers of these magazines, in the very large majority of cases, are not of the character which are shown to be necessary to ensure safety, and which are adopted in Government magazines." It is also asserted that consumers' magazines, belonging to persons who buy for use and not for re-sale, are marked by great carelessness in the management. Still worse is the case on the retailers' premises; this trade is carried on without license or regulation, and there is "no supervision with regard to the place or mode of storage, or over the persons by whom such retail trade may be carried on." Carriage seems to be as defective as storage, for "no adequate provision is made for the public safety as to the proper package or modes of conveyance for explosives when transported from one place to another; or for forbidding the transport, loading, or unloading of dangerously large quantities through cities and populous places." Lastly, "the present law does not in any way regulate the importation or exportation of gunpowder." All these facts tend to show that this dangerous substance is not under sufficient control in regard to making, storing, carriage, importing, exporting, and retailing.

In relation to the numerous other explosives, one only is under express legislation; the "Nitro-Glycerine Act" forbids the manufacture of this substance and its compounds, except by license from the Secretary of State. In other cases, "there is no adequate legal provisions for regulating the manufacture, storage, transport, importation, or shipment of explosives of this class. The law relating to the chlorate or fulminate class appears also to be insufficient for the public safety. With regard to the ammunition and firework classes, the committee find that, while the law fails to provide adequately for the safety of the public and the persons employed in those trades, it is in some respects unduly restrictive and inconvenient to the persons engaged in them."

The recommendations made by the committee for the cure of these evils are embodied in a series of rules, to form the clauses of a new Act of Parliament, which the committee advise should be brought in and passed in the session of 1875. That something of a precautionary nature should be introduced, whether by legislature or by the ingenuity of practical men, is evident enough. The terrific explosion of nitro-glycerine on board a ship at Panama in 1866; the less fatal, but still very serious, explosion at Newcastle-on-Tyne in 1867; the explosion in the same year at the Berger stone quarries, near New York; the explosion at Sydney, New South Wales, in 1868; the more tragical explosion at Quenest, in Belgium, in the same year; and the blowing up of a nitro-glycerine factory at Stockholm in the same year—all showed the need for more stringent precautions. Nor have later years been wanting in illustrative instances—as witness the blowing-up of two nitro-glycerine magazines in 1870, at Painsville, in the State of Ohio; the explosion at a dynamite factory, at Cologne, in the same year; the utter destruction by explosion of the Stowmarket gun-cotton factory in 1871; the explosion of dynamite at the Durdham Downs Tunnel, near Bristol, in 1872; and others which have led to a lamentable loss of life.

POISONING WATER BY CHEMICAL WORKS.

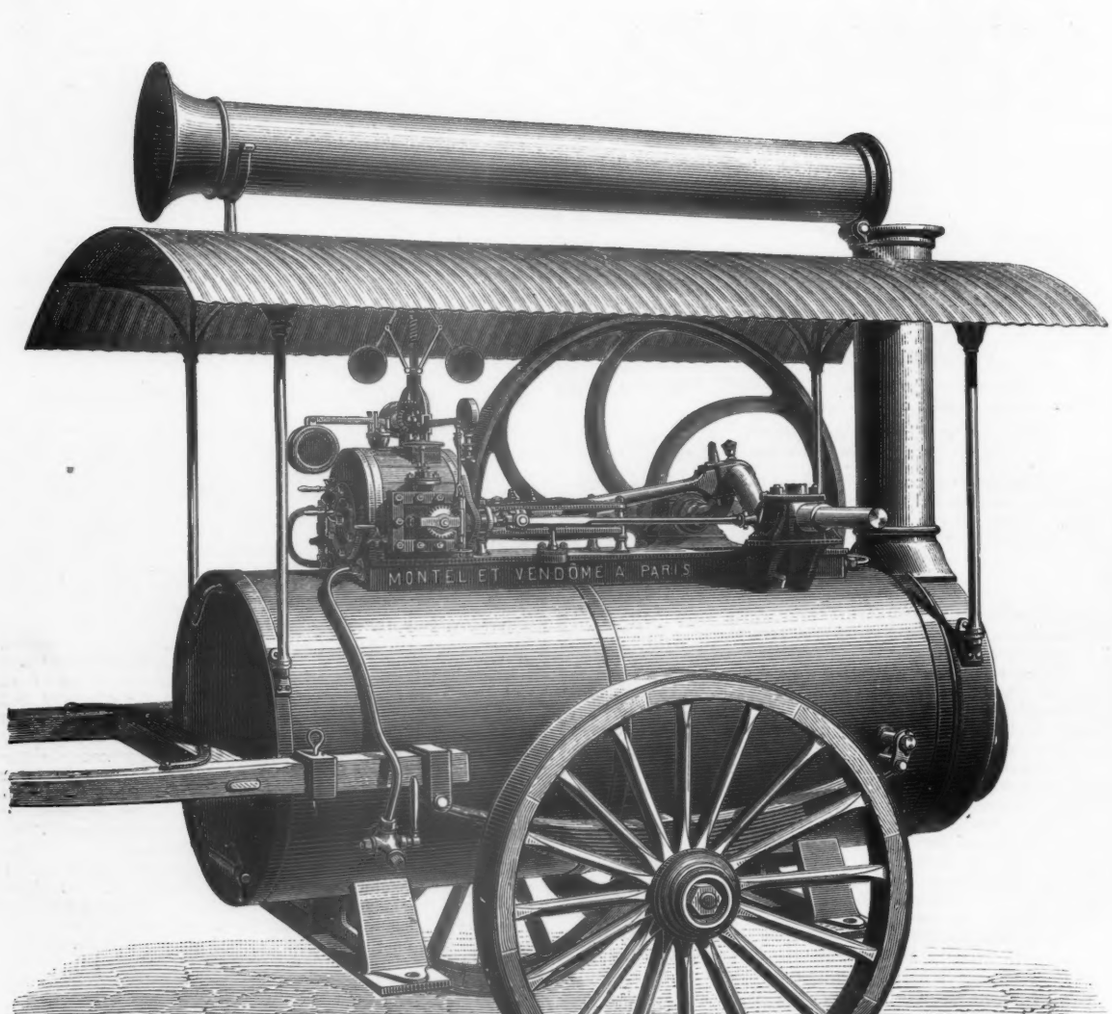
A VETERINARY correspondent of the "Agricultural Gazette" calls attention to the dangers arising from the leakage or infiltration, sometimes unobserved, of obnoxious refuse from chemical and other manufactories. He writes:—"In a recent issue of your journal I observed a reference to the death of four bullocks from 'Splenic Apoplexy.' As the facts of a case which seems to me to be identical with the above have come to my notice, I consider that they may be interesting to you or to your readers, and therefore lay them before you. On Thursday, July 14, a butcher bought thirteen bullocks in the Metropolitan Market, and sent them on that day to the marshes of Stratford, London, E. On the following Saturday the purchaser consulted me in consequence of finding four of them dead in the marsh. I made a careful examination of the locality, and discovered that the tidal ditches, which alone supplied the animals with water, were almost dry, the only water supply being in proximity to a chemical factory in which the process of eliminating arsenic from aniline colour refuse is carried on. I further observed water percolating, or rather oozing, through the banks of a reservoir used on the premises into the ditches, impregnating the water, already stagnant in the ditches, with poison. Two cows, many ducks, and numberless fish, besides the four bullocks already referred to, have died through drinking the water. I presented these details to the local sanitary authorities, who have them under consideration, with the view of preventing further losses by dealing with the source of the evil. I am sure I need not comment on the necessity of pure water for the use of our domesticated animals, and the care over tidal ditches, in the neighbourhood of manufacturing towns, where they form the main water supply."

PORTABLE ENGINE WITH REMOVABLE FIRE-BOX.

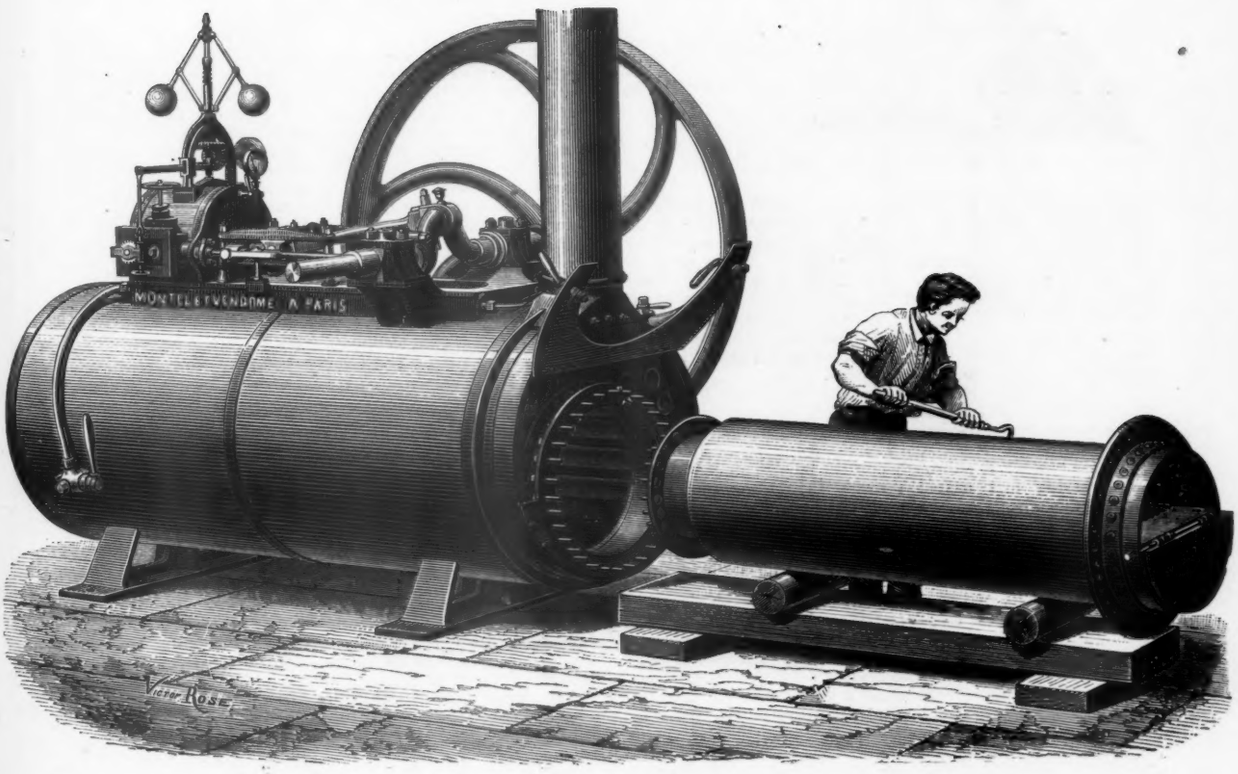
OUR engravings, on pages 306, 307, illustrate a new portable engine with removable fire-box, designed and constructed by MM. Montel and Vendome, Paris. We give the following description of it from the "Revue Industrielle:"—The engine is mounted on a novel axletree, with springs, an arrangement which permits rapid and easy transit over the worst roads. When it has arrived at its destination, the wheels are removed by means of a lever, and the engine then rests on its two rigid supports, thus avoiding the vibration inherent to all portable engines working on their wheels.

The boiler is tubular, the fire-box being movable while the tubes are fixed. The joints of the fire-box are completely immersed. Above the boiler is fixed an effective dry steam-chest. The engine is mounted on a light frame, and the cylinder is steam-jacketed. The expansion-gear is variable, and regulated by the governor. The feed-water is passed through a heater, before being pumped into the boiler.

XUM



MONTEL AND VENDOME'S PORTABLE ENGINE. FIG. 1.—MOUNTED, AND READY FOR TRANSIT.



MONTEL AND VENDOME'S PORTABLE ENGINE. FIG. 2.—DISMOUNTED, AND FIRE-BOX REMOVED.

XUM

The whole workmanship is carefully wrought, and the engine may be recommended for its good qualities, while the prices are comparatively low.

The boiler has a heating surface of 13 square feet per horse power.

The prices range from £180 for an engine of four-horse power to £800 for thirty-horse power.

Fig. 1 shows the engine mounted on its wheels; the machinery is protected from the weather by a corrugated iron roof; this adds to the cost from £20 to £28, according to the size of the engine.

Fig. 2 represents the engine dismounted, and the fire-box removed, for the purpose of cleaning. The arrangement is very simple and expeditious; two joints only have to be broken, and the fire-box is removed on two rollers, giving the means of removing the incrustation from the tubes, and the interior of the boiler.

SOME RECENT EXPERIMENTS WITH A FIREMAN'S RESPIRATOR.[1]

By JOHN TYNDALL, D.C.L., LL.D.

IN vol. clx. of the "Philosophical Transactions," 1870, p. 337, I refer to certain experiments on the "floating matter of the air," which were afterwards considerably expanded, and in part described in my "Fragments of Science." These experiments, in which my object was to obtain optically pure air by filtration through cotton-wool, suggested to me the notion of a fireman's respirator. Cotton-wool had been previously employed by Schroeder and Pasteur in their experiments on spontaneous generation.

I had heard that smoke was a formidable obstacle to the fireman, and that cases of suffocation were not rare; hence the desire to construct a respirator. My first trials were made with cotton-wool alone. Associated with the respirator was a mouthpiece with two valves; through one the inhaled air reached the lungs, having first passed through the cotton-wool, while through the other the exhaled air was discharged directly into the atmosphere. The smoke was generated in small rooms, and in some experiments in a cupboard; but though the irritation of the smoke was greatly mitigated by the cotton-wool, it was unbearable for any considerable time.

The cotton-wool was next carefully moistened with glycerine, no clots which could intercept the air being permitted. The respirator was distinctly improved by the stickiness of the fibres of the wool; still, when the smoke was very dense, an amount of irritation continued which materially interfered with the usefulness of the respirator. Thinking it certain that the mechanically suspended matter would be intercepted by the moistened wool, I concluded that this residual irritation was due to the vaporous hydrocarbons generated during combustion; hence thought of associating with the cotton-wool Dr. Stenhouse's excellent device of a charcoal respirator. The experiment was successful. With this combination it was possible to remain with comparative comfort for half an hour, or even an hour, in atmospheres, a single inhalation of which, without the respirator, would be intolerably painful.

Captain Shaw, of the Metropolitan Fire Brigade, has worked energetically towards the completion of the respirator by associating with it a smoke-cap. Mr. Sinclair has done the same, and he informs me that the respirator is now in considerable demand.

Having heard from Captain Shaw that, in some recent very trying experiments, he had obtained the best effects from dry cotton-wool, and thinking I could not have been mistaken in my first results, which proved the dry so much inferior to the moistened wool and its associated charcoal, I proposed to Captain Shaw to bring the matter to a test at his workshops in the City. He was good enough to accept my proposal, and thither I went on the 7th of May. The smoke was generated in a confined space from wet straw, and it was certainly very diabolical. At this season of the year I am usually somewhat shorn of vigour, and therefore not in the best condition for severe experiments; still I wished to test the matter in my own person. With a respirator which had been in use some days previously, and which was not carefully packed, I followed a fireman into the smoke, he being provided with a dry wool respirator. I was compelled to quit the place in about three minutes, while the fireman remained there for six or seven minutes.

I then tried his respirator upon myself, and found that with it I could not remain more than a minute in the smoke; in fact, the first inhalation provoked coughing.

Thinking that Captain Shaw himself might have lungs more like mine than those of his firemen, I proposed that he and I should try the respirators; but he informed me that his lungs were very strong. He was, however, good enough to accede to my request. Packing the respirator with greater care, I entered the den with Captain Shaw. I could hear him breathe long, slow inhalations; and after the lapse of seven minutes I heard him cough. In seven and a half minutes he had to quit the place, thus proving that his lungs were able to endure the irritation seven times as long as mine could bear it. I continued in the smoke with hardly any discomfort for sixteen minutes, and certainly could have remained in it much longer.

During this time I was in a condition to render very material assistance to a person in danger of suffocation.

The smoke-cap I wore was one made by Mr. Sinclair, which has a mouthpiece similar to that used in the inhalation of nitrous oxide. But, to show the care necessary in packing the respirator, it is only necessary to remark that, with the packing furnished to me by Mr. Sinclair, it was not possible for either myself or Mr. Cottrell to continue in a dense smoke for more than three minutes; and even these were minutes of laborious breathing. Flannel discs are employed in these respirators, but I cannot recommend them. Cotton-wool, carefully moistened and teased, is, in my opinion, much better.

It is always possible to associate fragments of lime with the respirator, thus, if necessary, intercepting a portion of the carbonic acid. But in most fires we have a more or less free circulation of air; and I venture to think that not in one case in a thousand of actual fires would the combination of smoke and carbonic acid be so noisome as it was in the experiments here described.

[1] "Proceedings of the Royal Society," vol. xii. p. 359.

GLASGOW PORT WASHINGTON IRONWORKS, OHIO.

THE formal inauguration of the practical operation of making iron at the Glasgow Port Washington Ironworks, Ohio, was celebrated on August 14, with considerable rejoicing. We are indebted to the "Mining Journal" for the following account of the progress of the company, its works, and its mineral properties.

It was in the year 1871 that a number of wealthy and enterprising Scotchmen in the city of Glasgow conceived the idea of investing some of their surplus capital in the manufacture of iron in the United States; and having heard highly favourable reports of the facilities offered by Tuscarawas county, in the State of Ohio, they sent out their agents to that district to make a thorough investigation in regard to its mineral resources, the prices of land, and all other necessary information connected with their contemplated enterprise. The report was favourable, and accordingly, in the early part of the following year, a limited liability company, having a capital of £250,000, was formed in the city of Glasgow, under the name of the Glasgow Port Washington Iron and Coal Company.

The objects of the company were (1) the acquisition of two valuable mineral properties in Tuscarawas county, about 2½ miles from the town of Port Washington, quite adjacent to Newcomerstown, and about 100 miles west of the "Iron City" of Pittsburgh; (2) working the useful minerals contained in them; and (3) the erection of works for smelting the ironstone. The available means of transit to and from the works are of an excellent character, inasmuch as the properties owned by the company are situated in the immediate vicinity of, and have access to, the Ohio State Canal, by means of which Lake Erie and the Ohio River are connected, while by the Pittsburgh, Cincinnati, and St. Louis Railway there is direct connection with the city of New York and other important cities and towns in the States. Including the two properties acquired by the company, there is an area of about 860 acres, throughout the whole of which there is a rich and abundant supply of minerals, chief amongst which is a seam of blackband ironstone, which crops out on the surface of the country, and can be worked on the "open-cast" system. That seam of ironstone varies from 3 ft. to 10 ft. in thickness, and has an average of 6 ft.; total estimated quantity amounting to fully 2½ million tons, and being capable of affording a sufficient supply for two large blast-furnaces for thirty or

forty years. Assuming that the mineral wealth now owned by the company consisted of blackband ironstone alone, the cost represents only about 6*d.* per ton of royalty value, whereas the royalty value of a similar quantity of an equally good deposit of the mineral in the county of Lanark (where the blackband was first discovered as a valuable ore of iron by David Mushet) would amount to nearly £200,000. There are other useful minerals, however, in addition to the one just spoken of—clayband and ball ironstone, five seams of workable coal ranging from 2 ft. 6 in. to 8 ft. in thickness, together with extensive deposits of fire-clay and building stone. The company also own about 12 acres of land within a convenient distance on the Cadiz Branch Railroad, from which they obtain their supply of limestone for fluxing in the blast-furnace and for building purposes.

When the company was launched and the shares taken up, arrangements were at once made for commencing mining and other operations forthwith. For a time, however, owing to some hitch, those operations made comparatively little progress, but eventually active steps were taken, and great energy was brought to bear on the management. In the month of September last year the business of brickmaking was started, and there are now erected two splendid and capacious blast-furnaces, together with the other necessary structures, such as the engine-house, &c., and in the construction of which about two-and-a-half millions of bricks have been employed.

Report speaks very highly of the two new blast-furnaces that have been erected at Port Washington, as they bear such a very favourable comparison with most of the furnaces in use in the various iron-smelting districts of the United States. They are 70 ft. high, 17 ft. 6. in. in diameter at the boshes, and closed in at the top on the bell and cone system, so that the gases may be utilized in the manner that is now becoming so general in this country. The original intention, we believe, was to construct the upper part of the furnaces in accordance with the self-coking principle of Ferrie's patent; but that intention, from some cause or other, has not been carried out. In the meantime, a mixture of raw coal and coke is used in the furnaces, the coke being obtained at Connellsville, Pennsylvania, and stored in an immense frame, the foundations of which are 18 ft. below the level of the railway by which it is brought to the works. From experiments now in progress at the works in the manufacture of coke, and which have succeeded beyond the most sanguine expectations that were entertained regarding them, it is confidently anticipated that the company will eventually be able to make good serviceable coke from their own coal.

There are two ranges of boilers, four in each, for supplying the necessary steam-power, and water is drawn from the Ohio Canal at a point about a mile distant from the works, and pumped up and forced to its destination by steam-power, a reservoir or cistern capable of containing about 125,000 gallons being provided for keeping up the supply. The engine-house is highly spoken of, and the blowing-engine is said to be a piece of work that is not excelled in the State of Ohio. It was constructed by an eminent Pittsburgh engineering firm (Messrs. M'Intosh, Humphill, and Co.), and is provided with a blowing cylinder 84 in. in diameter. Although the engine was erected 100 miles away from the works where it was constructed, not a single piece was wanting or unsuitable for its place. The work of superintending the erection of the machinery was entrusted to Mr. John Stevenson, jun., late of Glasgow, but now retained by the Port Washington Company as their mechanical overseer. It may here be mentioned, that not only is the projection of the Port Washington establishment entirely due to the enterprise of Scotch capitalists, but all their principal servants at the works hail from Scotland, including Mr. Wm. B. Rennie, the general manager, Mr. A. Crookston, the engineer-in-chief, Mr. A. Fleming, the furnace manager, Mr. J. Fleming, founder, and Mr. Coats, mechanical engineer. Furthermore, it has been generally agreed to apply the term "Scotch pig," or "Scotch-American pig," to the pig-iron produced at the works, the minerals and system employed in its manufacture being so very similar to those employed in producing those famous brands that have so long been special favourites with American founders and engineers.

When the two furnaces are in good going condition, it is confidently expected that their joint products will amount to about 420 tons per week. The probable cost of the work as at present designed, will be from three-quarters of a million to one million of dollars, exclusive of the cost of the land. The company are manufacturing their own fire-bricks for use in the furnaces, and erecting lime-kilns, &c. We understand that it is not their intention to proceed to the manufacture of finished iron; at all events, they will not do so in the meantime. The inauguration of the practical manufacturing operations has been so auspicious and successful, that there is every reason to feel confident that a long and prosperous career is in store for the company; that is certainly the unanimous sentiment of the people of Tuscarawas county in regard to the undertaking.

We may mention that since the news regarding the commencement of practical manufacturing operations at the works was received a few days ago in Glasgow, the Port Washington shares have advanced from 39*s.* to 55*s.*, £6 being paid on the original £10 shares. There is every probability, therefore, that the improvement now set in will become a permanent one.

EXPERIMENTS ON THE TENACITY OF MALLEABLE METALS AT VARIOUS TEMPERATURES.[1]

By M. A. Baudrimont.

THE following memoir on the tensile strength of the principal malleable metals at different temperatures, addressed by its author to the Academy of Sciences at Paris, seemed to me to contain so much both curious and useful in engineering, that I have translated it for the "Journal," as it has never before appeared in English. The results with iron in particular are very singular in many respects, proving that metal to be an exception within certain limits—and the only one so far as known—to the general law of decreasing tenacity in function of increasing temperature.

The ingenious experimenter has omitted to state whether he experimented on the same piece of iron wire at the different temperatures, or on different pieces; and, if the former, whether he experimented first at the lower and afterwards at the higher temperatures, or the reverse; for, if he experimented with the same piece of wire, and at the lower temperatures first, as was probably the case, the results are not quite conclusive, as will appear from the following considerations:—

That no piece of iron wire has precisely the same tenacity at every point of its length, is absolutely certain; consequently, there must be a weakest point, a next weakest, and so on. Now, when the wire is first stretched, to rupture it, it will yield at the weakest point, showing a certain tenacity; if it be thus stretched again, it will yield at the next weakest point, showing a greater tenacity than the previous one, and so on, showing for each successive stretching an increased tenacity. If the first stretching takes place at the lower temperature, and the next at the higher one, the difference in the two tenacities shown is attributed to the difference of temperature, whereas it may be due to the fact that the wire at the point of rupture in the second case, had, for equal temperatures, a considerably greater tenacity than at the point of rupture in the first case. What is really shown by such experiments, is the difference of the tenacities at the two points of successive rupture with equal temperatures, modified by the influence of the different experimental temperatures.

The experiments made on the tensile strength of wrought iron in 1837 by a committee of the Franklin Institute, had first shown the anomalous fact of its increase with the increase of temperature between certain limits of the latter. And, in 1853, Mr. Fairbairn published his experiments, demonstrating the same truth. These, together with the experiments made by Baudrimont in 1843, and detailed in the following memoir, constitute all the knowledge we possess on the subject.

In the experiments by the committee of the Franklin Institute, however, the same piece of iron was successively ruptured, and gave, as a general result, just what might have been expected, namely, increasing tenacity at each rupture under ordinary atmospheric temperatures; but the committee failed to detect the reason, and left the naked fact standing in their tables without explanation. The experiments made by the committee under high temperatures, were vitiated by the same cause, as they were made on the same piece of iron after it had been broken—often several times—under low temperatures. The committee did not perceive that the greater tenacity of the iron observed under the high temperature might be due to the fact that the iron was then necessarily fractured at a stronger point than under the preceding low temperatures; but they compared, in all cases, the tensile strength obtained from the first trial under lower temperatures, with the tensile strength obtained under the high temperature, often after several fractures had been made under the low temperature, and the weakest points thereby eliminated. The tenacity thus found under the high temperature was, of course, as much too great, comparatively, as the tenacity under the low temperature, for the number of fractures made exceeded the tenacity at the first fracture under

[1] Translated from the "Annales de Chimie et de Physique," series iii. vol. xxx. p. 304, 1850, by Chief Engineer B. F. Isherwood, U. S. N.

the low temperature. Yet, obvious as is this deduction, the committee ignored it, and attributed the entire increase of tenacity shown under the high temperature to the influence of that temperature alone, while, in fact, this increase was mainly, if not wholly, due to the elimination of the weakest points by the several previous fractures of the iron made under low temperatures.

As far as I am aware, this fact of the necessarily increasing tenacity of the iron at successive fractures as a consequence of the continued elimination of weaker points by each preceding fracture, is now pointed out by me for the first time. The failure to perceive it, caused Professor Walter R. Johnson to attribute an actual increase of strength conferred on the iron by the simple process of stretching, whereas this result was solely due to the removal of weak points. Combining this error with that of the increase of strength assumed to be due to high temperatures, but really due to the same cause, led him to propose what he termed the "thermo-tension" treatment of iron as a means of increasing its tenacity. The whole principle of his process, however, being based on fallacious assumptions, its practical application proved worthless.

The conditions under which the experiments of Mr. Fairbairn were made, and particularly the fewness of their number, do not, in my opinion, justify any positive conclusions.

From a careful comparison of all the experiments I have been able to collect, concerning the influence of temperature on the tenacity of wrought iron, there results that, between the temperatures of zero and 550° F., this influence is exactly null, developing the important practical fact that, between these limits no provision need be made by the engineer for effect of differences of temperature.

B. F. ISHERWOOD,

Chief Engineer, United States Navy.

About sixteen years ago, I conceived an idea that the laws of the cohesion of homogeneous substances, that is to say, those laws which control the reciprocal action of their molecules, might be ascertained experimentally. The idea could not be immediately realized in consequence—as always happens in opening a new road—of the numerous obstacles to be in turn surmounted before advancing farther. In order, therefore, to overcome the difficulties that opposed the accomplishment of my project, I made a programme of the indispensable preparatory researches requiring completion before an approach could be even commenced toward my principal object which included the investigation of the constitution of wire-drawn metals, and of their elasticity and tenacity. In 1835, I had the honour to communicate to the Academy the researches on the constitution of wire-drawn metals, which have been inserted in the "Annales de Chimie et de Physique," 2nd series, tome lx.

There resulted from these first researches, that metals acquire permanent properties only after careful annealing, and that the different methods of working them, such as hammering, rolling, and wire-drawing, by causing notable changes in their volume produce, at the same time, considerable modifications in their tenacity.

In April, 1837, I undertook experiments on the elasticity of metals. They were made by the method of stretching, for copper, iron, silver, platinum, gold, lead, and tin. I found from those experiments, conducted by a process easy and exact to put in practice, that the lengthening of wire-drawn metals was proportional to the weight applied up to the instant of rupture; a result which M. Wertheim has since obtained from a series of observations not less numerous and not less positive.

I have not been able to publish these experiments because, in a theft committed at my house, the instrument used for measuring the relative diameters of the wires was stolen, and unfortunately I did not know its unit. Nevertheless, I had obtained sufficient results for the object proposed, and for even still more.

It was only in 1843 that I could undertake the third set of experiments, the one relative to the tenacity of the metals and which is the subject of the present memoir. Since that date, M. Wertheim has published the results of researches analogous to mine, but as he did not experiment at the temperature of 32° F., and has left omissions in relation to copper and palladium, besides not having operated by the same process, I believe I ought to submit them to the judgment of the Academy.

The direct results of the experiments are given in the following tables:—

Diameter of the Wires at 60°·8 F.

Copper	0·017 716 860 inch.
Gold	0·016 240 455 „
Platinum	0·016 142 028 „
Silver	0·015 679 421 „
Palladium	0·015 649 893 „
Iron	0·006 889 890 „

Experiments on the Tenacity of Wire-Drawn Metals at 32° *Fahrenheit.*

Name of the metal.	Duration of the experiment in minutes & seconds.	Weight, in pounds, producing rupture of the wire.	Mean of the weights.
Copper	6·38	10·108,720,000	10·015,018,666
	9·10	9·921,317,333	
Gold	2·37	5·613,260,877	5·421,448,741
	2·24	5·150,266,067	
	2·36	5·500,819,280	
Platinum	2·20	6·468,698,905	6·585,549,976
	2·40	6·702,401,047	
Silver	2·39	7·859,888,070	7·779,047,706
	2·26	7·760,674,896	
	2·32	7·716,580,153	
Palladium	3·29	10·119,743,686	9·981,947,612
	3·19	9·844,151,538	
Iron	3·40	10·975,181,714	10·886,441,042
	3·53	11·125,103,843	
	4·30	10·847,306,957	
	3·44	10·598,171,655	

Experiments on the Tenacity of Wire-Drawn Metals at 212° *Fahrenheit.*

Name of the metal.	Duration of the experiment in minutes & seconds.	Weight, in pounds, producing rupture of the wire.	Mean of the weights.
Copper	2·56	8·768,239,797	8·725,798,601
	3·90	8·666,821,880	
	2·55	8·796,901,374	
	2·57	8·671,231,354	
Gold	2·11	4·528,530,181	4·487,375,087
	2·11	4·645,381,252	
	3·47	4·288,213,828	
Platinum	3·28	5·280,345,562	5·613,260,877
	1·36	5·943,971,454	
	1·35	5·615,465,614	
Silver	1·51	6·149,012,013	6·388,777,182
	2·40	6·735,472,104	
	1·53	6·395,942,578	
	2·29	6·274,682,033	
Palladium	3·35	9·001,941,932	8·888,397,967
	3·60	8·774,854,002	
Iron	3·35	10·099,901,051	10·165,491,982
	3·25	10·066,829,993	
	4·12	9·835,332,589	
	3·46	10·659,904,297	

Experiments on the Tenacity of Wire-Drawn Metals at 392° *Fahrenheit.*

Name of the metal.	Duration of the experiment in minutes & seconds.	Weight, in pounds, producing rupture of the wire.	Mean of the weights.
Copper	4·54	7·302,089,561	7·267,916,135
	3·28	6·673,739,463	
	4·80	7·915,006,500	
	3·13	7·180,829,016	
Gold	0·45	3·737,029,531	3·797,659,803
	0·46	3·858,290,076	
Platinum	1·30	4·814,705,067	5·030,328,291
	1·17	5·002,548,676	
	1·19	5·273,731,130	
Silver	1·10	5·134,832,974	5·102,864,252
	1·50	5·070,895,529	
Palladium	1·34	6·581,140,502	7·407,916,947
	1·54	7·650,438,037	
	1·58	7·992,172,301	
Iron	3·10	11·310,301,767	11·149,355,950
	3·10	11·237,545,433	
	3·20	10·900,220,650	

The metals experimented on were copper, gold, platinum, silver, palladium, and iron. They were drawn into wire, and all, with the exception of the iron, made to pass through the same hole. The iron wire was smaller, because otherwise it would have required too great a weight to fracture it.

I operated successfully at 32° F. in melting ice, at 212° F. in boiling water, and at 392° F. in an oil-bath heated very slowly, the temperature of which was measured by a mercurial thermometer.

The wires had been annealed with a great deal of care, and were placed horizontally in a cast-iron vessel containing the liquid forming the bath. This vessel was suspended by weights attached to chains passing over pullies, which allowed it to be raised or lowered at will for conveniently arranging the wires within it. The furnace for heating the liquid when operating at the high temperatures, was mounted on a wheeled frame-work so that it could be instantly run on one side in order to lower the vessel.

The wires being small in diameter, and good conductors of heat, would evidently quickly acquire the temperature of the bath, and remain constantly at it notwithstanding the heat developed by the stretching to which they are subjected. One of their extremities was fixed immovably to an iron support; and the other, by means of a light strong chain guided by three pulleys, was attached to a zinc receiving-pan, into which dry sand was arranged to run from a box containing it, with a velocity controllable at will by a more or less inclination of the box. When the wire was ruptured the zinc pan, in falling, struck a handle which closed a valve that instantly arrested the flow of sand. The zinc pan and the sand it contained were then weighed on a well-made, strong, and very sensitive balance.

The diameter of the wires was measured at the temperature of 60·8° F. by callipers sensitive to the $\frac{1}{3540}$ of an inch.

Although the experiments recorded in the preceding tables were made under very favourable conditions for uniformity, it is none the less true that they present considerable differences in the results; nevertheless, these differences are within such limits as to show with precision that the tenacity of the metals varies with the temperature to which they are subjected, and according to determinable laws.

In a theoretical point of view, the maximum tenacity obtained should be the nearest to the truth, for in the experiments there was nothing to increase the cohesion of the molecules of the metals, while on the contrary, many circumstances might diminish it; but in a practical point of view, the mean result must be adopted, for it has more chances to be correct in application.

The following table has been constructed according to this principle; and it contains, additionally, the tenacity of the metals on which I operated, calculated for one square inch of cross section. This calculation permits, further, the comparison of the tenacities of the different metals with each other.

There results from these experiments:—

1. That the tenacity of each metal varies with the temperature.
2. That, generally, it decreases—but not without exception—as the temperature rises.
3. That for silver, it diminishes more rapidly than the temperature rises.
4. That for copper, gold, platinum and palladium, it diminishes less rapidly than the temperature rises.
5. That iron presents a particular case and a very remarkable one. At 212° F., its tenacity is less than at 32° F., but at 392° F. it is greater than at 32°. M. Wertheim has likewise obtained an analogous result. The experiments, furthermore, have been repeated a sufficient number of times to leave no doubt in that respect.

If the tenacities be taken for ordinates, and the temperatures for abscissas, and the points thus obtained be joined by straight lines, there will appear by simple inspection of this graphic trace that, if the tenacity of the iron ought to be represented by a symmetrical curve, the minimum of tenacity would fall a little below 212° F.; but should the variation in the tenacity of the metal be due to a new arrangement of its molecules, causing, as a consequence, a variation in the latent heat, then, by as much as that result is probable, should the minimum of tenacity be beyond 212° F., and the line which represents it ought to jut up suddenly and parallel to the ordinates.

Tenacity of the principal malleable metals at the temperature of 32°, 212°, *and* 392° *Fahrenheit, in wire of the diameter and cross section experimentally found; and for one square inch of cross section as given by calculation.*

Name of the metal.	Diameter of the wire in fractions of an inch, at 60·8° Fah.	Cross section of the wire in fractions of a square inch, at 60·8° Fah.	Tenacity in pounds at			Tenacity in pounds per square inch of cross section at			
			32° Fah.	212° Fah.	392° Fah.	32° Fah.	212° Fah.	392° Fah.	
Gold . .	0·016,240,455	0·000,207,152	5·613,260,877	4·645,381,252	3·858,290,076	27,907	22,425	18,625	Maximum.
			5·421,448,741	4·487,375,087	3·797,659,803	26,171	21,662	18,338	Minimum.
Platinum .	0·016,142,028	0·000,204,648	6·702,401,047	5·943,971,454	5·273,731,130	32,751	29,045	25,770	Maximum.
			6·585,549,976	5·613,260,877	5·030,328,291	32,180	27,429	24,580	Minimum.
Copper .	0·017,716,860	0·000,246,522	10·108,720,000	8·796,901,374	7·915,006,500	41·005	35,684	32,107	Maximum.
			10·015,018,666	8·725,798,601	7·267,816,135	40·625	35,395	29,482	Minimum.
Silver . .	0·015,679,421	0·000,193,086	7·859,888,070	6·735,472,104	5·134,832,974	40,706	34,883	26,593	Maximum.
			7·779,047,706	6·388,777,182	5·102,864,252	40,288	33,088	26,428	Minimum.
Palladium	0·015,649,893	0·000,192,362	10·119,743,686	9·001,941,932	7·992,172,301	52·608	46,797	41,547	Maximum.
			9·981,947,612	8·888,397,967	7·407,916,947	51·891	46,206	38,510	Minimum.
Iron . .	0·006,889,890	0·000,372,834	11·125,103,843	10·659,904,297	11·310,301,767	298,393	285,915	363,360	Maximum.
			10·886,441,042	10·162,491,982	11·149,355,950	291,991	272,655	299,043	Minimum.

Further experiments are indispensable for solving this problem, which is one of great interest, not only in a theoretical point of view, but also because it appertains to the most commonly used metal, and the one always employed in the construction of steam boilers.

PHOTOGRAPHY AT THE BOTTOM OF THE SEA.

DR. NEUMAYER has recently exhibited before the Berlin Geographical Society a photographic apparatus designed for the determination of the temperature and of the currents at great depths in the ocean.

The invention is composed of a copper box, hermetically sealed and furnished with an exterior appendix made like a rudder. In the interior is a mercury thermometer and a compass, each enclosed in a glass receptacle, in which are admitted traces of nitrogen gas. A small electric battery commands the apparatus. When the latter is allowed to descend, attached to a sounding line, the action of the current on its rudder causes it to assume a parallel direction, thus indicating the set of the flow by the relative position of compass, needle, and rudder. The thermometer, of course, shows the surrounding temperature. In order to fix these indications, a piece of photographic paper is suitably disposed near the glass cases containing the instruments. Then at the proper time a current of electricity is established through the glass in the receptacles, causing an intense violet light, capable of acting chemically upon the paper for a sufficient length of time to allow of the photography thereon of the shadows of the compass needle and of the mercury column. Within three minutes, it is said, the operation is complete, when the apparatus is hoisted and the paper removed.

XUM

BILLIARD-TABLE MANUFACTURE.

THE history of our celebrated manufacturing houses shows that the improvements which have been so remarkable as to elevate an entire department into a higher range of excellence than had hitherto characterized it, and thus gave position to a whole class, have been the production of the individual labours of some single house, which, having reached the accredited standard, sought to attain a meritorious distinction by rivalry, that by becoming superior to all they might distance all competitors by a generation. The history of the pianoforte supplies a ready and familiar illustration. It was by the union of the personal labours and particular advantages of the several firms of Kirkman, Brinsmead, Cramer, and others in their several excellences, that the present comparative perfection of that instrument has been attained. But for them, we should still be groping among theorists to the mockery of practical art.

So is it with the billiard-table. In 1814, Mr. Thurston set about a work of improvement in construction which, while it demanded the effort of his characteristic energy and personal skill, practically made a new instrument. He foresaw that the billiard-table was destined to become a conspicuous item in the catalogue of a gentleman's belongings, and determined to deserve the highest rank of merit in its manufacture by a distinctive excellence. That position was by his brethren and by the public soon yielded, and time has only given its undisturbed ratification. Amid the inevitable jealousies and rivalries of competition, none would venture to challenge the assertion that the prize of renown is still the reward of those who hold the name and traditions of Thurston.

In laying before our readers the information acquired by a visit to their works, we shall not excite trade jealousy, and shall be doing a good service to the manufacturing and reading public by supplying useful knowledge to many who may not find it ready to their hands. Encyclopædias never furnish sufficient of the information that a well-informed man seeks to gather; such materials can only be collected amid the dust of the factory, and the busy whirl of its machines.

The works at Cheyne Walk, Chelsea, cover an area of 50,000 feet of irregular shape, but covered on all sides by buildings arranged for the convenient transit of each branch of the manufacture in succession, until the "Fitting-Room" is reached, with the least possible waste of labour-power.

After passing a long avenue of timber-plank, the area becomes square, and the first room the visitor enters is the slate-room—a very appropriate arrangement, for two reasons: first, because the foundation of the whole fabric is of course the table; and second, because it is to Mr. Thurston we are indebted for the discovery of slate as the most suitable material. This was, in fact, one of his earliest improvements. Formerly the bed was made of wood; many pieces of geometrical form, and of differing directions of grain, were glued together, mosaic fashion, aud the surface then planed down, and made smooth with great care and skill. Besides the use of wood, many experiments had been made to find some artificial compositions that would be an improvement on wood, and obviate the serious inconveniences of that substance when employed in constructing the bed and in playing the game. Since then, metal foundations of various kinds have been introduced, only to be displaced by what is now everywhere recognized as the inevitable slate. This singular geological production is specially adapted for billiard-tables, because it is not affected by changes of temperature, as every other material is, and because of the ease with which it can be manipulated. And in playing the game it affords a further advantage, in that the velocity of the ball can be indefinitely increased, and the direction of its path more correctly ensured. In fact, so far as *aim* is concerned, it matters not upon these improved tables—slate—whether the ball travels fast or slow.

The selection of slate is, however, a matter of much importance. As is well known, it is in itself a result of "a general cause, acting subsequently to the deposition and disturbance of the strata;" and although such disturbance was general, and slaty structure abundant, its nature being affected by the material which was disturbed, there is great difficulty in obtaining the particular kind for this purpose. There is but one stratum that has yet yielded good slate, and the best of that cannot be obtained in anything like abundance. The quarries of Bangor, in North Wales, alone furnish the most valuable kind.

But the maker of common billiard-tables could not afford so costly a material; hence the employment of some West Scotland slates, which contain iron pyrites, or those of Cumberland, containing fragments of other objectionable substances. Black Portugal slate is very much used by inferior makers, because of its cheapness; but it has to be used in much thicker substance than Bangor slate, because it is soft and friable, and even then it is not to be depended on.

The slate basis of a good table is usually in four pieces, and their preparation is a very interesting process. The slab is laid upon a table, and a powerful planing machine applied to its surface. The moving power is steam, and chains are employed instead of the ordinary leather or gutta-percha driving band. The plane is a small heavy block properly adjusted and fixed, having the usual plane-edge, and is about six or eight inches in width. This little individual can take half an inch off the surface of the slab in a few minutes; but if the crystals of cubical iron assert their presence, the slate surface is likely to be a greater sufferer than the machine. When the proper thickness has been arrived at, the slab is transferred to another table, there to have its edges made perfect. This is also a steam operation, and is effected by a succession of circular-saws of different sizes, having a vertical action of great swiftness and accuracy. The operation of squaring being completed, a third table is used. Here the corners for the insertion of the pockets are carefully chiselled to shape; and then is performed an especially important process call *dowelling*. This consists in drilling certain holes in the side edges of the slabs, and inserting brass pegs for the purpose of effectuating a perfect union of the edges, and a perfect uniformity of surface. The principle of this operation resembles that adopted in the insertion of extra leaves in dining-tables, and must be very correctly done. But there are other holes to be drilled, and upon their exact formation the stability of the table absolutely depends. These are in the sides of the slabs which touch the outer frame, and are made to receive the powerful screws which will have to pass through it. These holes are pierced to the depth of about three inches into the side, and then the slabs are turned over, and a hole drilled on the under surface so as to bisect that made in the side. Into this cavity is inserted a nut; and, as we shall see in the fitting-room, the vacuity is filled with lead after the screw is firmly and satisfactorily adjusted, and the union of frame and table is perfected for ever.

Another table is employed in this room for producing the required surface, which of course has not been effected by the plane. Here we learn that while modern machinery is all but omnipotent, there are processes which are beyond its operation. For scientific accuracy of surface to a billiard-table the ancient mason form is necessary. This is by drawing a heavy toothed rubber across backwards and forwards in every direction by hand, and using grit and water as the workman requires. A good surface cannot be secured by any other method. Long straight-edges are used for testing the work as it proceeds, and, of course, the labour is tedious. But in a factory where character is everything, the old adage "nothing without labour" is taken for granted.

In every department of this range of workshops the observer will note the same indifference about economizing time, patience, labour, and even cost, if their outlay will realize the object aimed at—perfection. He will not wonder that a first-class table is a costly article, for with the least acquaintance with factory management he can see how 30 or 40 per cent. can be saved and yet keep up appearances; but it would be at the expense of honesty in material, workmanship, and skill.

On leaving the slate-room the turning-shop is entered—that is, the wood-turning, for the ivory-turning is still done at the London house in Catherine Street. These artizans are engaged upon mahogany and dark English oak, and *solid* is the only word to be employed in the description. Nothing that comes out of that place can by any conceivable probability perish except by fire. Some thousands of well-seasoned blocks are there, or in the sheds below. They are about 12 in. by 8 in. and 10 in., and when first received a vertical hole of 1 in. or 1¼ in. is made through them; this assists evaporation and prevents cracking during the period of "seasoning." A curious application of art is shown in a custom of this factory. The blocks of English oak are cut up into sections, because that wood has frequently defective parts, and the best sections selected and re-united. It is a serious increase of cost, but it enables the manufacturer to remove the defective part and substitute a sound piece; so far from being a detriment it is an advantage, for, well-seasoned, it is after that incapable of splitting.

The work of turning is of the ordinary description, the only speciality being the employment of specially made tools; for it is more like working upon metal than wood, so firm is the texture, so hard is the grain, and so dry is the substance. The skill required to work on steadily and obtain the requisite natural finish involves costly labour of which some idea is given by the

fact that artizans of experience are able, by "piece-work"—which here, as in most best factories, is the rule of the house—to make a return of twenty shillings and more a day. The tools need not be described particularly. The principle is common to all tools used in lathes—they have edges; but the forms adopted are the result of years of experience, observation, and experiment, and could be of little general interest if described.

The general shop is much like an ordinary cabinet-maker's or joiner's workshop, only that everything has but one use, and that is to make billiard-tables. After the wood has been seasoned by time one would suppose the manufacturer could depend upon its future good conduct, but not so. It would seem to be impossible to trust a piece of timber after any period of probation. The strong frame is made of the very best oak, or mahogany, of some 2 in. thick, which will not yield in heated rooms or in public rooms of variable temperature. Here a cheap maker of tables gets his advantage. Who is to know if common deal is used for the inner and main material when it is covered up by veneer? and who is to know whether less expensive, commoner woods are employed, if choice veneer conceals every portion of the interior from the purchaser's observation? A shrewd man of business, as such dishonest reasoners are termed, would, in going through, detect many places where a sovereign could be saved in material and in labour. Veneering is indispensable, but by its abuse we have come to associate hypocrisy and deception with the very term. Veneer should, in all honesty, cover only material of its own nature or such as is of equal worthiness for durability and substance. It ought not to cover rascality, but be the outward adornment of inward excellence. Pollard oak veneers are employed, but they are used to cover sound oak. Some of these sheets are of the most exquisite beauty, and the rough everlastingness of the solid part has a covering worthy of its strength in their service. The grain of choice pollard veneer is remarkable for its charming attractiveness. A thousand pounds is soon spent in a very choice selection, for like rare books or pictures, when a man can get possession of a parcel, he had better avail himself of the opportunity. It is money to him although so apparently insignificant. So is it with mahogany. We are not writing on woods and their adaptations, but every practical man knows there are few woods in which variety of quality exists to the extent it does in mahogany, both as to nature, strength, texture, and beauty. The choicest has to be sought for the service of the best billiard-table maker, whilst the cheaper will serve for the worthless, shaky, unlasting imitations. In this shop the ordinary processes of joinery are carried on. Clamps, presses, glue-pots, are all about in the orderly confusion proper to all industrial proceedings; but since stability is the chief property of the article to be produced, there is a profusion of those useful contrivances. Before being united, every piece has to be made perfectly to fit, be perfectly smooth and level, so that no space is left for a redundance of glue; but that when the parts are put together, no particle of air shall remain to be affected by time or temperature. Certainly these constructions could never wear out, or tremble, or even by accident become disabled; and it is pleasant to an observer, and satisfactory to a purchaser, when "behind-the-scenes" at an English factory shows such operations.

From these the polishing-shop is reached. The same care and pains mark all that is performed here. Instead of applying assorted dyes wherewith to turn beechwood into walnut, or pine into mahogany, or pear into ebony, and the thousand-and-one hypocrisies of the age, the artizans are busy in slowly and incessantly administering small doses of spirit, &c., and large quantities of arm-friction, in order to create the honest transparency which shall bring into bold front the inner and otherwise unrevealed charms of that wonderful product of nature, the grain of the wood. Here the wood, so well selected, is made to glow, and the refinement of excellence is enabled to exhibit its natural superiority.

The cushion-stuffing room is the adjoining one. In this department great changes have been made since the amusement of billiard-playing was introduced, both in the material employed, and in the material afterwards made general. These changes are protected, or have been, by patents granted to Mr. Thurston. Formerly the cushion was stuffed with list of several widths applied one over another, until the desired shape and thickness was obtained. This was at once the most pliable and firm material to be found; but india-rubber is the substance now used, and the most delicate combination of pliancy and firmness is the result. A rebound is secured by the slightest touch, and that was not the case with list. In its ordinary form it is cast to the shape required, and comes from the india-rubber works in lengths like picture-frame moulding; it is then cut to proper lengths, and fitted and fastened in the usual way of working rubber. This was found to be a vast improvement, and was indeed perfectly successful when the tables were placed in large public rooms, where from constant service the room is seldom under the temperature of 60°; but it was unsatisfactory very often when the table was placed in small rooms, and used only two or three times a week. In winter the rubber would be as hard as wood at the beginning of the evening, and only become pliable as the room became heated. The player could not depend upon his cushion-stroke. Contrivances were adopted for introducing hot water through hollow zinc tubes, which were inserted in the thick parts of the india-rubber cushion. Thurston, having a leading private trade, after much experiment succeeded in producing a vulcanized rubber not affected by temperature. Strips of this are taken, as list formerly was, of different widths, and built up to the form required under the dexterous manipulation of experienced hands, who know how to use solution, and how to work their heated irons briskly and carefully. The singular perfection of elastic firmness in these cushions is well known as a characteristic, and is in great favour with players. It would seem to be a matter of indifference, but an observer who should contrast the two cushions would be astonished at the superiority, and might learn a lesson applicable to other things than billiard cushions. In this room the silver pocket-plates for best tables, and the brass plates generally used, are applied.

The lamp and gaslight-room is an interesting one. Here the specialities in artificial light are constructed. The desideratum is light without shadow, and much ingenuity has been exercised to this end. The variety is almost endless, since practical and decorative art are both under tribute, as the pattern book will show. In this place are crucibles; turning lathes for metal; polishing apparatus, appliances, and contrivances; and lacquering preparations in full working. As the "brass work in general" is also brought to this room, the variety in shapes, styles, and adaptations is very great. The billiard-room has to be lighted in a manner different from every other part of the mansion, and yet with an elegance and refinement in keeping with it all. This gives to the gaslight-room a special interest: there must be as good a variety as in an ordinary lamp warehouse, but very different in pattern and construction—in fact, a separate branch of the trade. Designs for billiard lamps is one of the branches which modern habits have given to remunerative art, and there is always scope for good patterns, and fair reward for the work. Cue fittings, or rather rests, are among the quaint shapes and devices manufactured here.

We are introduced to the fitting-room at last, where all these component parts are brought together and, for once and for all, united. Legs, sides, bed, pockets, brass or silver work, green cloth are here introduced to each other, and it is interesting to see the effect of accuracy in detail when the several parts are tested. Very rarely is there any adjustment required; all things have been so well ordered and mathematically produced that scarcely any rectification is demanded. All being ready, the large screws which pass through the sides into the bed are put in, the nuts, of which we spoke in the slate-room, are fitted, and the lead is run in, which secures against every contingency the union of sides and bed; the table is then covered, and the pockets are fitted; and the ivory or silver plate announcing the maker's name being affixed, the table is sent away to be a pleasure to performer, purchaser, and maker.

Cues, whether of the common or expensive kind, are made of ash-wood. It is found to be the best material; but the great difference in value of cues makes explanation necessary. They range from shillings to pounds. The best have great pains spent on them, whilst the common are merely shaved up, and wax-polished. The cue cannot be made by machine, but must be the result of gradual manual operations; for ash-wood has a trick of warping or casting, that would be fatal to half the cues a machine could turn out. The plank is cut into square strips, and seasoned, and then first made into octagon or hexagon shape, then hung up for two or three years. Then they are further reduced, and again put by; and so on for a very long time, until perfect straightness and correct form are obtained. In some, the handles are cut down to a square, and layers of ebony or rosewood, and birds'-eye maple and other fancy woods laid on, which after being shaped to the cue pattern and finally polished, have a very nice effect, at a moderate price. Others have flowers inlaid in the most elaborate manner, and of every colour known to floriculture; but the best and worst must use the ash-stick as the lightest, and the truest, and the best-balancing material that can be selected.

The process of turning the balls need not be particularly described, as it does not properly belong to billiard-table manufacture. The ivory is purchased in considerable quantities, cut up like bits of cucumber, of the size that would include the ball. These are roughly rounded, and then properly seasoned. After being kept for some time, they are put into the lathe by the use of the "chuck," and turned to shape, and then and there duly

XUM

polished. Those intended for red are dyed by the means of boiling in a mixture of scarlet leaves, alum, and other ingredients — which a common cyclopædia will state — and then polished.

M. C. CLAMOND'S THERMO-ELECTRIC BATTERY.

THIS apparatus, of which the following drawings give a representation, transforms heat directly into electricity. A jet of gas is lighted within the centre of the apparatus, which altogether does not occupy more space than an ordinary laboratory furnace, and suffices to produce an electrical current, both energetic and constant. The expenditure of gas is relatively very small. It is consequently not difficult to estimate the great advantages which this simple apparatus offers to chemists in their experiments, and still more to electrotypers and others who may require a continuous production of the electric current without the annoyance and expense of extensive apparatus.

Several different forms of thermo-electrical batteries had already been devised, among others that of Mr. Farmer, but they all more or less presented certain inconveniences, the principal of which was the rapid loss of force, and also the fragility of the bars employed, which, in cooling, were liable to crack and split. In 1869, M. Clamond invented, together with Mr. Mure, a thermo-electric battery, which was presented to the French Institute by M. Becquerel. It was formed of couples of galena and bars of iron. This apparatus proved that the loss of power was not so much owing to the diminution of the electro-motive force, as to the increase of the resisting power of the apparatus. Though the result obtained did not eventuate in rendering the couples of galena more durable, it still had the effect of giving to the bars, and to the general arrangement of the apparatus, a certain favourable disposition, which M. Clamond has adopted in his battery, and which has not yet been found capable of improvement.

Further experiments proved that the increase of interior resistance was owing to two causes :—

1st. The oxidation of the points of contact of the bars of polarization with the bars which crystallized under the influence of heat.

2ndly. The splitting of the bars and their separation into different parts according to planes perpendicular to their length.

The first difficulty was obviated by a peculiar arrangement of the polar joint. That is to say, that the metallic sheet, cut in two, is bent back upon itself so as to present several joints. These joints taken in the run of the metal, are bound up in the

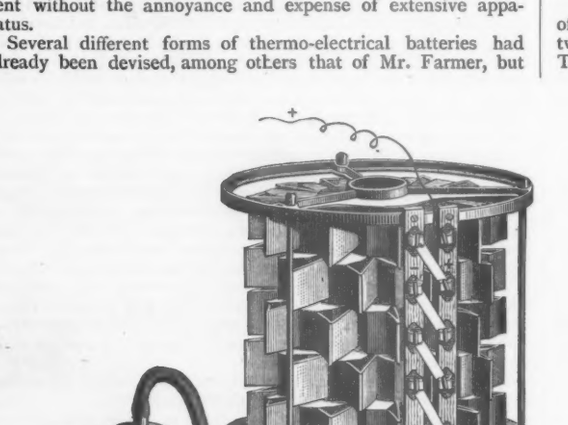


Fig. 1.

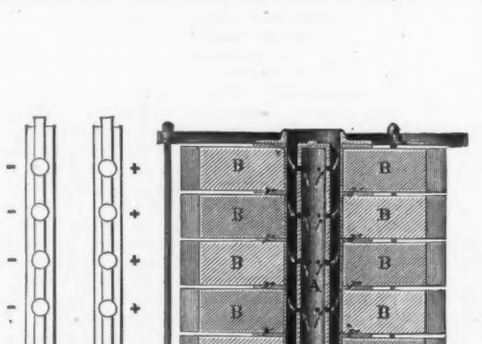


Fig. 2.

metallic substance itself, which fills the joints and so forms a sort of knot or nucleus, which, under the action of heat, becomes distended, and renders the contact more absolute.

The second difficulty was of a more serious nature and not so easy to counteract, for when a thermo-electric substance, either a metal or a metallic sulphide, is poured into a cold mould of cubic form, three planes of division are always formed, which are easily discernible by the black lines parallel to the faces of the cube, formed by the oxidation of the different surfaces, the result of which was that the mould actually contained eight different cubes. It was therefore necessary to neutralize the effects of the sides of the mould and to prevent crystallization as much as possible.

In order to obtain this result, the moulds themselves were heated to nearly the same degree as the point of fusion of the thermo-electric substance, and this substance was poured into the moulds at a temperature very nearly approaching to its point of solidification. For his couples, M. Clamond employs an alloy of zinc and antimony, recommended by Marcus, and the armatures are composed of sheets of iron. The alloy of zinc and antimony is an excellent conductor of electricity, and its point of fusion renders it favourable to the process of moulding described above.

The iron armatures are also preferable to those of copper or other metals, as they resist better, and are not so liable to be acted upon by the alloy.

The thermo-electric bars constructed upon this principle have given excellent results, and are found to be less liable to deterioration than others.

The following is the arrangement of the apparatus :—The bars are arranged in crowns, and coupled for tension. These crowns, composed of ten bars each, are ranged one above the other, and separated by disks of asbestos.

The whole forms a cylinder of which the interior surface is luted with asbestos, and heated by means of a tube of fire-clay pierced with holes. The gas, mixing with the air, quits the interior of the tube, and enters into combustion within the annular space comprised betweeen the tube and the bars. The extremities of the bars are joined to copper forks fixed upon two little wooden planks. The couples can be joined by tension, or by surface. Used for electrotyping purposes, a deposit of about three-quarters of an ounce of pure copper may be obtained per hour.

The quantity of gas required is regulated by means of M. Giroud's rheometer, which renders it constant and devoid of intermittence.

The apparatus, thus arranged, is capable of being employed for whole months without expense or supervision, and supplies an absolutely constant current.

An apparatus of this kind, such as is represented at fig. 1, causes an expenditure of gas of one half-penny per hour; and in electrotyping operations, the deposit of 1 kilogramme of copper costs only two shillings (the kilogramme = 2 lbs. 67 hundredths).

This apparatus is employed in the printing-office of the Bank of France, and in the electrotyping works of Messrs. Goupil and Co. at Asnières, where it renders great services, to the entire satisfaction of the director, who is more and more pleased with it every day.

Fig. 2 represents a section of the apparatus and its interior arrangement.

T. Tube through which the gas passes from the regulator.—A. Tube of fire-clay pierced with holes, through which the gas passes to burn in contact with atmospheric air, in the annular space between the bars and the fire-clay.

D. Entrance for atmospheric air.

B B. Thermo-electric bars.—*r r* rounds of asbestos, serving to isolate the elements of the generator.

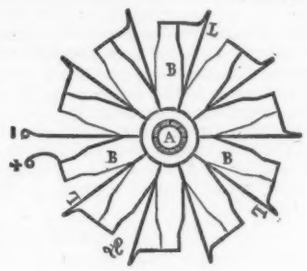


Fig. 3.

Fig. 3 represents a plan of the bars and of their armatures.

B B. Thermo-electric bars.

L L. Sheets of iron composing the armatures.

The apparatus can be constructed of different dimensions and power, according to order. It is most efficacious and economical, and particularly for electrotyping purposes is much to be recommended for the small space it occupies, and for its easy manipulation and great economy.

F. MOIGNO.

"DINAS" FIRE BRICKS.

WE have recently had brought to our notice the "Dinas" fire bricks made at the Abernant Iron Works. They contain about 96 per cent. of silica in their composition, rendering them capable of resisting the greatest heat, a quality of great importance in the white heat of steel and copper furnaces, where the ordinary fire brick is comparatively worthless. At the same time, they will not stand the chill so well as the common fire-brick which, in iron furnaces, may be used again and again. The export of these bricks to Russia is reckoned by millions, and at Krupp's extensive establishment at Essen in Prussia, none but the "Dinas" bricks are used.

CAST-IRON PAVEMENT.—A contractor has lately received permission to put down at Liége, by way of experiment, a new cast-iron pavement. The quay d'Avroy has been chosen for the scene of operations, and near the Rue Sainte-Véronique, on the "macadam," between the footway and the tramway, on the American system, this new pavement has been laid. Over a bed of concrete a layer of asphalte is spread, and in this substance the cast-iron paving blocks, which are four centimetres (1½ in.) thick, are set. The experiment has been made on a sufficiently large scale to give this new invention a fair trial.—*La Métallurgie.*

FOREST CLEARING BY STEAM.—A. GILCHRIST proposes to pull up trees by the roots by means of the traction engine used in steam-ploughing. Experiments carried out at Bonerbo, near Anstruther, Fifeshire, recently were highly successful, and indicate that the reclamation of forest land in Canada and elsewhere may be readily attained by this means. The process is very simple. A traction-engine, of 12-horse power, is stationed some distance off from the wood, and a wire chain is fastened to the tree. Steam is then put on, and the tree is pulled forcibly out by the roots. An objection to the adoption of the process was that it would injure the wood by splitting the tree, but the experiments showed that with proper precautions there was no fear of such a result. In the course of five hours upwards of 300 trees in a plantation nearly 100 years old were pulled out. Of that number, not above half a dozen were broken, and in these cases the result was wholly due to the inexperience of the ploughmen engaged in the work, who placed the chain too high up the tree. *Iron, No.* 79, *p.* 77.

Practical Literature.

AN ELEMENTARY TREATISE ON STEAM.[1]

THIS handy little volume is one of Messrs. Macmillan and Co.'s excellent series of school class books, and is chiefly intended for the use of students who can solve simple equations in algebra, and who know the simple definitions of trigonometry and the simpler facts in physics.

It treats, in separate books, on heat, and its general effects, on matter, expansion, the connection between work and heat, convection, conduction, &c., and steam as applied in steam-engines, locomotive and marine.

In dealing with the first section of his subject the author would seem to have overlooked the recent expositions of the laws of the conservation of energy, and the consideration of heat as a mode of motion which are so ably expounded in Professor Balfour Stewart's valuable treatise on "The Conservation of Energy."

The remaining three sections deal in a very complete manner with the varied applications of steam to engines, and form a really valuable practical aid to the student to whom the larger works of Bourne and Rankine—which in some measure the present volume supersedes as giving more complete and accurately worked out results—are inaccessible.

In dealing with the locomotive, the details in connection with and dependent upon its employment—such as the permanent way, &c.—the author has presented in a very small compass an admirable exposition of the practical uses and developments of steam power, and the last book, on the marine engine, is not less complete. Several tables of hyperbolic logarithms, diameters, areas of circles, specific gravities, &c., are appended to the volume, which, with its carefully prepared index, will take rank as one of the best in the useful series of which it forms a part.

We do not think the author is always so clear and precise in the language of his definitions as is necessary in a treatise of this kind; this, however, is a fault which tends but slightly to impair the value of what is, on the whole, a much needed and valuable little treatise.

THE STORAGE OF WATER.[2]

FORTUNATELY England enjoys an immunity from such devastating droughts as those which are so calamitous in their results to the subjects of our Eastern Empire, but it not unfrequently happens that very large districts of our own country often suffer very severely from a scarcity of water, and it is only one more evidence of the unscientific character of most of our administrations which are in the hands of corporate bodies, that no practical methods of alleviating the distress occasioned by these droughts have been devised.

The author of the pamphlet before us remarks, and as we think with great show of truth,—that "it would almost seem to be the object of our legislature on *sanitary matters* to first encourage us to do wrong,—then to point out the error we have committed,—and finally to leave us without any power of rectification." This certainly seems to be the case with regard to that portion of our sanitary economy which Mr. Denton has set himself to consider in the present pamphlet, and while not hoping at the moment that any *general* scheme for the storage of water will receive attention, he fairly anticipates partial action as the result of recurring droughts like those which were experienced during the past summer.

We sincerely trust that this pamphlet may have the effect of attracting attention to this subject of bringing about some practical results. The matter is an important one; the author has discussed it both in its broad scientific aspect, and in its more particular applications, and we recommend its careful consideration to all who are interested in this branch of sanitary economy.

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[1] *An Elementary Treatise on Steam.* By John Perry, C.E. London: Macmillan and Co.

[2] Reprinted papers with additions. By J. Bailey Denton M. Just, C.E. F.G.S. London, E. and F. N. Spon, 1874.

XUM

SULPHUR IN ICELAND.[1]

IT is somewhat remarkable, considering the important part which sulphur occupies in our commerce and manufactures, and the fact that it must be present in nearly all districts which manifest volcanic agency, that we are confined to so limited an area from which to draw our supply. The object of the present pamphlet is to consider the circumstances which may lead capitalists to seek for this productive mineral at a shorter distance from our shores than the Mediterranean or Mexico; and naturally on surveying the likely districts nearer to this country, Iceland would be almost the first to claim attention. After adducing numerous testimonies to the fact of the abundant presence of that mineral in the island, almost all of which concur in pronouncing the supply to be practically inexhaustible, the author gives a full description of the property which has been secured by Mr. A. G. Lock, for the mining of sulphur in Iceland, together with some details of their working, upon the results of which he has been able to frame a comparative estimate showing the difference in the profit accruing from working Sicilian and Icelandic sulphur. It would appear upon this that in the former case the utmost profit that can be realized is from £2 to £2 10s. per ton, while in the latter at least £4 per ton can be cleared. The analyses of Iceland sulphur show that in quality it is equal, if not superior, to that which is ordinarily imported.

That such a rich field of so valuable an article of commerce has been so little availed of by English capitalists is no doubt to be attributed largely to the conservative character of the people of the island; but this is an obstacle which could no doubt be easily overcome, inasmuch as it has already been broken down in the case of the mines above referred to.

The pamphlet is illustrated with two maps, and a view of the Great Geyser, and is dedicated to Captain R. F. Burton, of whose description of Iceland the author has availed himself in his work.

TABLES SHOWING THE SCREWS THAT CAN BE CUT ON SLIDE LATHES.[2]

THIS is a much needed compilation, not because similar works are not already before the public, but because it is constructed on a plan which facilitates reference in a much more complete manner than, for example, Morton's well-known Tables, &c. Instead of arranging the screws in the order of the wheelwork, as in the tables just referred to, the compiler has arranged the whole of the screws which ordinary wheelwork will cut with a 20-pinion wheel, in terms in the order of the screws, thus rendering it possible to see immediately what pitches can be cut without the trouble of hunting through several pages to ascertain whether the size pitch required exists.

The tables are printed in five columns, each headed in plain capital letters; the first column giving the number of threads, the second the wheel on mandril, the third the wheel on pinion, the fourth the wheel on intermediate, and the fifth the wheel on screw. It will be obvious that with this arrangement—with the list of Whitworth's standard threads and sizes appended—they are much more compact and easy of reference than the tables in common use.

Foreign Practical Journals.

Zeitschrift des oesterreichischen Ingenieur-und Architekten-Vereines. Parts xi. and xii. Vienna, R. v. Waldheim, Taborstrasse, 52.

THE Austrian North-West Railway are having new engines built for their express trains, to a pattern first brought out in 1857 by Maffei of Munich, and since improved upon by v. Kessler in Esslingen.—Prof. J. Wist reports upon the workman's house at the Vienna exhibition, giving a history of the various attempts made at artisan accommodation. A large number of plans accompany this report.—Lifts and hoists have come into greatly extended use in Austria lately, owing to the increase in the cost of land leading to the erection of taller houses and loftier manufactories. Herr Freissler describes several varieties of lifts and hoists, of which he states he has himself erected 400 in Austria and Hungary during the past four years.—Prof. Dr. Winkler contributes a paper on the unification of the nomenclature of railway objects of all sorts.—A patent railway carriage coupling is described by M. Fuchs. It is worked by a lever from the side of the carriage.—G. Müller gives a formula for the calculation of the weight of wrought-iron bridges.

Der praktische Maschinen-Constructeur. No. 18. Leipzig, Verlag von Baumgärtner's Buchhandlung.

THE present number opens with a continued article on the apparatus necessary in the practical application of asphalt. Articles follow on modern mowing machines, on common mistakes in the use of conical forms in machinery, on the book-binding machines at the Vienna Exhibition, on the employment of superheated steam, and on the steam-boilers exhibited last year at Vienna.

Annales de génie civil. Aug. 1874. Paris, Lacroix.

AMONGST other articles of interest there is a communication from Dr. Beins of Amsterdam, concerning a proposed substitute for steam-power. It depends upon the expansion of liquid carbonic acid in a properly arranged apparatus. For convenience sake he gives to the liquid carbonic acid the name of carboleum. This carboleum he obtains by heating bicarbonate of soda in a confined space, when a part of the carbonic acid is freed, and liquefies in a part of the space which is not heated. At a temperature of 300° to 400° C., and under a pressure of from 50 to 60 atmospheres, liquid carbonic acid can be distilled at a cheap rate. A litre of "carboleum" at 15° C. and a pressure of 50 atmospheres, weighs 0·8 kilo., and will produce 400 litres of carbonic acid at the ordinary pressure of the atmosphere. The process is patented for Holland and several other countries.

Revue Industrielle. No. 30. Paris, Fontaine et Buquet, rue Saint-Georges, 52.

A STUDY of the beet-root sugar manufacture, by E. Riffard, is reprinted from the *Journal des fabricants de Sucre*.—Lesseps' proposal of a railway to India by way of Russia and Central Asia is reported on.—A new pattern locomotive, with eight wheels, six of which are coupled, is described, with drawings. It is engine and tender in one. The Belgian State Railway has several locomotives to this pattern now running, and ten have been ordered for the Luxembourg State Railway.—M. Radisson, of Grigny, Rhône, proposes a vertical fire-place for boilers, to be placed parallel to the longest axis of the cylinder. Perfect combustion of the fuel, and a regularization of heat, are the advantages claimed.

Le Technologiste. No. 404. Paris, Roret, rue Hautefeuille, 12.

AMONG the original articles in this number is an essay by A. Brackebusch on bleaching by chlorine. He says that better results are obtained by the permanganate of soda process, which is applicable to silk as well as to wool. Permanganate of soda and sulphate of magnesia are taken in equal weights, and dissolved in warm water; the stuffs, their greasy matters having been removed, are dipped in this bath till they acquire a brownish colour. They are then placed in a bath composed of 1 part sulphuric acid to 27 of water, and washed when the brown tint has disappeared.—J. Thomsen, of Copenhagen, describes a process for obtaining oxygenated water, or peroxide of hydrogen, pure, with ease and quickness. He decomposes the hydrate of peroxide of barium in sulphuric acid.—M. Rivière gives a process for extracting beet-root juice under steam at a high pressure.—Perrotte's system of indicating, by magnetic means, the level of water in steam boilers; De Tromenec's system of comparing the force of gunpowders; Deprez's method for the optical determination of the rates of projectiles; Ladiguin's apparatus for electric illuminations, are among the matters described in less detail.

Les Mondes. Tome xxxv. Nos. 2 and 3. Paris, abbé Moigno, 18, rue du Dragon.

PONSARD has a new and cheap process for the manufacture of carbonic-acid gas, richer than usual in carbonic acid. Oxide of carbon is produced in a gas generator, then brought into a reverberatory furnace, where it is burnt, and converted into carbonic acid at a high

[1] *Sulphur in Iceland.* By C. CARTER BLAKE, Doct. Sci. Hon. Sec. Lon. For. Anth. Soc. London: E. & F. N. Spon, 1874.

[2] *Tables showing the Screws that can be cut on Slide Lathes.* By H. L. London: E. and F. N. Spon. 1874.

temperature. A gaseous current is produced, which passing over chalk or other calcareous substances, decomposes them and carries away their carbonic acid, which is added to that obtained as a product of combustion.—A. Flament, member of the Agricultural Society of Brabant, states that the weevil, an insect so destructive to cheese, will quit any establishment in which hemp is laid about. The hemp should be sown early, and gathered before going to seed, and used fresh. —Dr. Picot, at an agricultural congress at Nuits, recommended the clipping of vines so as to retard their development until they were beyond danger from spring frosts. A viticulturist, M. de Belenet, described at the same congress the benefits resulting from the employment of a new mineral manure, which he does not describe, but which he states is found naturally in considerable quantities in the vine-growing districts of France.—M. Wurtz's speech at Lille, on the atomic theory in the general conception of the world, is reported at length. It was delivered before the French Association for the Advancement of Science. M. Wurtz, one of the most distinguished chemists of the present day, is dean of the Paris Faculty of medicine.—Dr. Fournier has papers on the instruction of deaf mutes.—An appreciative account is given of C. W. Vincent's improvements in the manufacture of alkalis; and a brief *résumé* of the last sittings of the French Academy of Sciences.

Bulletin de la Société Industrielle de Mulhouse. Nos. for June and July. Mulhouse and Paris.

THE contents of this beautifully printed journal are varied and important: it is to be regretted that its transmission is so tardy. M. Walther Trechsel gives the analysis of a new mineral not unlike binnite.—M. Ernest Zuber describes his method of deep well-sinking, which consists in pumping from the interior of the boring, the sand and gravel beneath the cylinder. He attributes the origin of the idea to a well-sinker, named Christ, of Schiltigheim, but states that the method has not hitherto been described. A full set of drawings accompanies the article.—A new fire-extinction apparatus, depending on the use of water subjected to pressure obtained from steam, is described by the engineers who fixed it, Messrs. Goerig and Engel-Royet. It is fixed in the bleaching works of Hoeffely and Co. at Pfastadt, and is connected with the general steam service of the factory. Work goes on night and day, Sundays and saints' days, and steam is therefore always under pressure.—In the manufacture of indiennes, M. Richard, of Keillinger's works, obtains a reduction of 60 per cent. of the steam heretofore necessary, a production of goods three times as great as before, and a reduction in wages, by a new process of steaming.—The gas meters of M. Giroud, which depend on the employment of glycerine, are reported on favourably. A dry meter by the same inventor is not considered satisfactory.—M. Ernest Stamm submits a project for piercing Mont Blanc in order to construct a new railway between St. Gothard and Mont Cénis. M. Stamm states that it would be more easy to make a tunnel through Mont Blanc than it has been to make one through Mont Cénis. The line would run southwards from Chamounix to Aosta.

Il Politecnico. Giornale dell' Ingegnere Architetto civile ed industriale. July and August. Milan, via Lupetta.

THE great church of S. Maria del Fiore in Florence is to have a new front. Sig. Marchesi discusses the plans submitted for its erection, favouring Antonelli's project for a basilica-like front rather than that of De Fabris, who has adopted the tri-cuspid system.—A description of the process for the decortization of rice in a large Italian factory is given by Dr. Coppitz. The system adopted is the so-called Belgian system. The concern is a large one for Italy, its floating capital amounting to two million francs.—E. Lombardini corrects certain popular errors in the geography of the Po, contained in recent Italian school-books, and even in maps published under the authority, respectively, of the Austrian and Italian governments.—A. Sayno proposes the description, and even, if necessary, the tracing on metal of curves and spirals, by an adaptation of the Archimedean screw. He calls his apparatus a "mechanical spiralograph."—The new railway (of two lines of rails) between the Vierwaldstättersee and Bellinzona, in the canton Ticino, passing through a tunnel pierced through Mont St. Gothard, is described by F. Ajraghi. This tunnel will be 14,800 metres long. —Captain A. Cialdi gives some preliminary notions for a treatise upon the construction of sea-ports in the Mediterranean. They are of a purely general nature, at least in the present part, and have no local or special application.

Nuova Antologia di scienze, lettere ed arti. September, 1874. Florence.

CONTAINS an article, with full details upon the subject of cremation, a matter in favour of which Italian traditions have something to say, and to which differences of climate and social habit give an aspect different from that under which it must for long be regarded in northern countries.—Some important considerations upon exhibitions in general accompany a description of the "Historical Exhibition of Industrial Art," at present open at Milan.

The Calcutta Review. Calcutta: Thos. H. Smith.

THE July number, the latest to hand, contains an account by Dr. Vincent Richards, of the literature of snake-poisoning for the last two centuries.

The Engine-driver's Manual. A Handbook for Railway Employés and Technical Students. By J. Brosius and R. Koch. Wiesbaden: C. W. Kreidel, 1874.

THIS is a complete guide to railway mechanics, and is well illustrated with woodcuts, lithographic plans, &c. It is considered one of the best works of its kind in German.

The Rational Course of Drawing for Elementary Schools. By L. d'Henriet. Paris: Hachette & Co.

THE author, M. d'Henriet, is a distinguished engineer and clever draughtsman, who wishes to make drawing form a part of ordinary elementary education. In the present day, much as technical and general education has improved, drawing is nowhere a very common workshop accomplishment, yet it is more common in France than in England.

Designs for Furnaces, Machinery, and Apparatus used in Iron-working. By U. Zoppetti, Engineer. Milan: B. Saldini.

THIS is an atlas of designs in 134 plates, with 418 pages of accompanying text, published at 50 francs, and designed to make the industrial world of Italy acquainted with the various methods of iron-working adopted in other countries. Hoffmann's and Siemens' furnaces and Martin's and Bessemer's processes are fully treated of.

Special Correspondence.

PARIS, *September* 20, 1874.

THE PHYLLOXERA.

ALTHOUGH essentially French, the question of the Phylloxera, the great question of the day, may still in more than one way interest the British public; I may therefore be permitted to devote a few words to the consideration of this subject. Since our national assembly has voted a recompense of £12,000 to the inventor (French or foreign) who shall succeed in discovering a means of protecting our vineyards from the attacks of the Phylloxera, the Academy of Sciences is overwhelmed at each of its meetings by a multitude of communications suggesting new methods for the destruction of this insect, or of preservation from its ravages. It is therefore necessary that inventors should be made aware that in order to compete seriously for the prize, they must prove by repeated, long-continued, and authenticated experiments that they are able to cause the Phylloxera to disappear from those vineyards which it has attacked, to preserve those vines which are still healthy, and to create new vineyards safe from attack. It is but natural that an inventor who imagines he has discovered a remedy fulfilling these conditions should wish to place his invention upon record; but the prize will only be granted after absolute proof of the genuineness of the discovery, and therefore, after actual experiment, fully authenticated, has enabled its value to be tested.

Two remedies, or rather two insect-killing substances, have proved to be sovereignly efficacious. In Cognac, M. Mouillefer, Professor at the Agricultural School at Grignon and Delegate of

the Academy, has tried with success the sulfo-carbonate of potash proposed by M. Dumas. In the proportion of $\frac{1}{1000}$ dissolved in a litre of water, this substance proved quite harmless to the plant, but at the end of a few days, owing to the toxic vapours it disengaged, it was able to mete out prompt justice to the devastating insect. But it was expensive, and it was necessary to discover a means of preparing it economically on a large scale. This problem was scarcely proposed than it was solved. It was the employment of alcohol which rendered the preparation of this salt slow and limited to small quantities. M. Valenciennes, director of the works of Dorvault's "Pharmacie Centrale de France," at Saint Denis, found that by reacting with strongly concentrated sulphide of carbon upon carbonate of potash, its transformation into sulfo-carbonate could be effected directly without the intervention of alcohol. Messrs. Romieu and Petit at Nîmes, M. Balbiani at Montpellier, on their side, tried coal-tar, and with entire success. The proportion of coal-tar required, several thousand kilogrammes the hectare ($2\frac{1}{3}$ acres) seems at present enormous, but by a judicious distribution of the substance there is no doubt that the quantity may be considerably diminished. This reminds me of a fact of which I was a witness in my youth, and which tends to prove that the ancient methods of agriculture and horticulture were not devoid of reason or wisdom. In Lower Brittany, where the climate is damp and cold, vines often suffer, and the grapes upon trellis-work do not always ripen. In order to overcome this difficulty great care was taken to surround the stems of the vines with a layer of soot obtained from the sweepings of chimneys. They were thus in reality supplied with tar, not the tar obtained from coal, for it was then still unknown, but that produced by the combustion of wood, which at that time was the only fuel used in Brittany.

Last Monday, the Phylloxera caused quite an excitement at the Academy of Sciences. In order to give additional interest to the exhibition of insects now being held in the orangery of the Tuileries, it was thought proper not only to show the Phylloxera in all its habitations and in all its forms, but also to make commercial stock of the same by disposing of living samples of the insect to curious amateurs. M. Dumas raised his voice, and declared that it was scandalous that at a time when every possible means is being tried in the provinces to arrest the progress of the evil, it should be brought to Paris to become an object of curiosity and of speculation, &c.; that this dangerous importation ought no longer to be tolerated, for the Phylloxera, slowly advancing from the south through the Beaujolais district towards Burgundy, would much more rapidly reach our vineyards in the east if it were enabled to make Paris its starting point. It is calculated that the Phylloxera would require perhaps seven years to reach Burgundy in travelling only from the south; but it is evident that its progress would be much accelerated if it started from Paris at the same time. The Academy therefore decided to entreat the government to put a stop as soon as possible to this dangerous speculation of the promoters of the exhibition of insects.

Artificial Vanilla.

Professor Hoffmann, the eminent chemist, whom all London knows and admires, whom England has reluctantly consented to give back to Germany, his native country, has considered it his duty to warn the Academy of Sciences that two German chemists, MM. Tiemann and Haarmann, are about to undertake on a very large scale the artificial manufacture of vaniline, the essential principle of vanilla, of which it possesses all the qualities in a most remarkable degree of excellence and concentration. For some time past it has been found possible to extract a substance in small quantities from the juice of the pine-tree, which possesses exactly the flavour and perfume of vanilla. Since then it has been discovered that very much greater quantities of this precious substance are contained in young trees, and every preparation has been made to work out the idea industrially. The vanilla merchants, who are not on their guard, are likely to suffer heavy losses, on account of the enormous depreciation in the value of that substance which will probably take place.

Here we see that to the artificial essence of almonds extracted from benzine by Mr. Claude Collas, and to artificial madder obtained from coal-tar, will soon be added artificial vanilla, extracted from the sap of pine-trees; and these conquests of science continue multiplying every day. Have we not been already threatened with artificial sugar at a farthing a pound?

Clarifying and Refining of Sugar and Syrups by the Use of Baryta and Basic Phosphate of Ammonia.

Upon this subject we wish to announce a most important improvement in the operations of clarifying and refining of sugar juices, which have hitherto been much neglected, and are very incomplete. The juices of beetroot and of sugar cane contain, in proportions which vary according to the country, the origin and mode of treatment, a sufficiently notable quantity of mineral and organic acids, combined with certain alkaline and calcareous substances, which have the effect of preventing the crystallization of an important part of the sugar, as much during the process of sugar-making as during that of refining. But baryta and phosphate of ammonia perform the chemical refining in the following manner:—The baryta, introduced into the boiler in equivalent proportions, combines with the mineral and organic acids, and forms with them an insoluble precipitate which is eliminated. Similarly, the bibasic phosphate of ammonia introduced into the boiler in proportions varying from 1 to 2 litres (1·7 to 3·5 pints), marking 10° Beaumé per kilogramme (2·20 lbs.) of baryta employed, forms an insoluble precipitate of lime with the calcareous matter. After the introduction of the baryta, and of the bibasic phosphate of ammonia into the boiler, the mass is heated to ebullition, when the ammonia evaporates, and is carried off with the steam, and the juice is fit to be carried on to the "Taylor" filters. Besides the chemical refining thus obtained, the baryta and phosphate of ammonia *clarify mechanically* the sugary liquor in a much preferable manner to that hitherto employed by the aid of blood and bone-black, because the barytic and calcic precipitates formed in the sugary liquor, like all precipitates at the *moment of their formation*, possess the property of carrying away with them nearly all the *organic matter, albuminous or gelatinous*, which remain in the juice.

This process of clarifying and refining, in order to be advantageous, should be applied to a sufficient quantity of first and second flow, and the density of the charge ought not to exceed from 25° to 30° Beaumé, so that the liquor may easily filter through the bags of the "Taylor."

This new method, which is now employed in many sugar manufactories and refineries in France and elsewhere, has produced excellent results for the juices both of beetroot and of sugar cane. The results in sugar-making can be expressed by a greater yield and a higher standard, and, in refining, by retarding the progressive formation of glucose, together with a larger amount of sugar refined, and a considerable diminution in the weight of molasses. The expense of setting up the necessary plant is insignificant, not to say absolutely nothing; the only apparatus required, besides those usually employed in all sugar works, being the "Taylor" filters.

In order to manufacture the raw products required in this process, a large company has been formed by the amalgamation of several others, which are the following:—The Chemical Works Company of Commines (Nord), formerly under the direction of M. Tessié du Motay; the Asnierès Company, directed by English chemists. Messrs. Maxwell and Lyte, the new company, are established with a capital of £160,000; their house of business is situated Rue le Pelletier, No. 20, and to them applications may be addressed for further details.

The Iron Trade.

One of our French engineers, M. Lencanchez, Member of the Society of Civil Engineers, has just made a communication of great importance, and which at the same time constitutes a revolution likely to lead to great future results. Messrs. Verdier and Micolon had succeeded in obtaining from ribbons cast-steel of excellent quality by means of a process which they kept secret, without being aware that their success was entirely owing to their having employed crucibles of graphite (plumbago) which they happened to have on hand, and that they would have been quite unsuccessful had they used ordinary fire-clay crucibles, because the presence of silica would have changed the nature of the reactions. M. Lencanchez has, in fact, proved that silica in contact with tribasic phosphates acts the part of sulphuric acid, and transforms them into monobasic phosphates and acids, which are decomposed, transforming the iron, as well in the smelting furnace as in the puddling furnace, into phosphate of iron.

The Rearing of Silkworms in Egypt.

England takes the most lively interest, and a very active part in the development of Egyptian industry. She hastened to endow that country with railways, and is glad to exchange her gold for its cotton. She will, therefore, rejoice to hear that she may possibly soon be able to obtain a portion of her silks from Egypt, and the eggs of silkworms (called, in French, the graine) required for importation to her colonies. It is now three years since the Khedive lent a favourable ear to the proposals of a most competent man, M. A. Gauthier, already for some years established in Egypt, and authorized him to commence trials of *sericiculture*, or rearing of silk worms. Notwithstanding the innumerable obstacles he had to encounter, M. A. Gauthier's efforts were crowned by the most brilliant success, the proof of which are the two golden medals awarded to his highness, the

Khedive, for silkworm eggs and cocoons exhibited by him. M. Gauthier is now dead, but his son, and one of his friends, M. Coppin, of Clermont (Oise), followed courageously in his footsteps; and I have heard lately from them that they are at the present moment in a position to offer to their countrymen in France their abundant harvest, consisting of 56 kilogrammes of eggs of the best origin—Japanese, French, Italian, reared in Egypt, according to the best methods indicated by M. Pasteur, and carefully selected by them, with the aid of the microscope, and guaranteed to be perfectly healthy.

These gentlemen are perfectly convinced that the entire zone of Lower Egypt, from about seven miles above Cairo, is one of the finest and most favourable localities in the world for the rearing of silkworms, on one condition, easily fulfilled, that the *magnaneries* (as the silkworm establishments are denominated in France) be so situated as to be, firstly, completely protected from the effects of the Khamsin, or hot wind; and, secondly, that they be not exposed to the dust, or other matters which might interfere with the cleanliness and pureness of the leaves. We feel certain that the European markets will accept with the utmost favour these perfectly healthy silkworm eggs of Messrs. Gauthier and Coppin, and that their laudable initiative will confer a great benefit upon the Egyptian government, and also upon the still unoccupied populations of the Delta.

Mineral Manure.

One of my friends. M. de Bellenet, instructing judge at the criminal court of Vesoul, made a great discovery about two years since, and which at the present moment is likely to become of very considerable practical utility. He found that the bituminous deposits of the schist of the lias, which is found in great quantities in the Jurassic deposits of the east of France, and which is also abundant in England and elsewhere, constitutes an unsurpassable manure, second neither to farm-yard manure nor to guano, but which completes them by adding to their properties, and is perhaps destined to take their place at some future date.

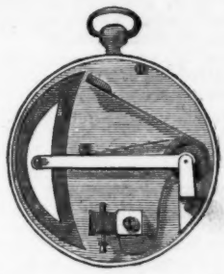
From the results of numerous analyses made in the laboratories of the school of the "Ponts et Chaussées," of the "Conservatoire des Arts et Métiers," and of the Agronomical Station of the East, followed by a great number of long-continued practical experiments, he proved that this new manure acts most powerfully upon vegetation in two very distinct ways: 1st, by the presence of the chemical substances it contains, such as potash, lime, phosphoric acid, and nitrogen, the fertilizing properties of which have long since been demonstrated, and universally admitted; 2ndly, by the successive disoxygenation and superoxygenation of the air in contact with three different bodies—oxide of iron, sulphur, and nitrogenized ligneous coal—of which the reactions had hitherto not been studied, and which until their perfect absorption, that is to say, during a long course of years, give rise to the production, to the benefit of the plants, of large quantities of ammoniacal salts and of nitrates. From the numerous experiments which have been made upon sick vines attacked by the Phylloxera, M. de Bellenet concludes that this mineral manure, so rich in sulphur, potash, mineral oils, bitumen, and special resinous substances, constitutes at once the most appropriate manure for the culture of the vine, and the most energetic insect killer. He does not hesitate to affirm that Divine Providence has without doubt in bounty vouchsafed to place the remedy by the side of the evil, and had created it in enormous and inexhaustible masses in the very centre of the afflicted region.

From now forward, our friend is ready to supply any quantities of this mineral manure to all those who may be desirous of making experiments, at the rate of 36 fr. 50 c. (£1 9s. 3d.) the 100 kilogrammes (220 lbs.), sacks included, and delivered at the railway station of Vesoul (Haute Saône).

Pedometer or Watch for Recording the Distance Travelled by a Pedestrian.

This little instrument is generally carried in the waistcoat pocket or in the fob, or else attached to a belt or to a button; the hook attached to the ring must be so fastened to the slit of the pocket or elsewhere that the instrument be always in a vertical position.

In never requires winding up, the first step of the pedestrian sets the works in motion; they continue to act as long as he moves, and stop when he stops. The dial is divided into twelve divisions, which represent so many kilometres, but can be adapted to record miles or any other measure of distance by means of a governing screw, which is square-headed, so as to be turned by a watch key; all that is necessary to do is to walk a mile, and then observe the position of the needle upon the dial; the regulator is then turned to the left for *slow*, or to the right for *fast* until one division on the dial represents exactly the measure of distance chosen, mile or kilometre, &c. This of course will depend upon the length of stride of each individual, and must be regulated accordingly.



When about to start the needle should be placed at zero, by turning the needle either backwards or forwards with the finger.

When the pedometer is not required to act, it should be carried with the ring downwards.

This useful little instrument can be obtained from the maker, M. Lafontaine, 18, Galerie Montpensier, Palais Royal, or from M. Victor Fleury, optician, 23, Rue de la Paix.

Price, in nickel, 26 francs; and in silver, 32 francs.

Fireless Locomotives.

One of the most important problems of the day, and which must be solved within a short time, and at any cost, on account of the ever-increasing number of tramways and street railways, is a locomotive or motor which can dispense with fire, and be equally applicable to every kind of vehicle, but particularly to those travelling upon iron or wooden rails on common roads. The readers of the "Practical Magazine" are, no doubt, aware that on several of the omnibus lines of New York and New Orleans horse power has been superseded by steam, produced from superheated water, and which is applied to the vehicles, at starting, from large charging boilers, where the water is heated under pressure to 356° F. The water is charged into tanks, jacketed with felt, asbestos, and wood (to prevent the escape of the heat), which are attached to the cars, and furnish the motive power; and they retain the heat so effectually, that a car so charged, and allowed to remain at rest for fifteen hours, still possesses sufficient steam pressure to travel at least half a mile. Each engine once charged is able to travel 7 miles, and is then charged again by the stationary boiler. One minute is all that is required to charge each tank. The economy realized by each of these street cars is four dollars a day, besides which they render good service, and are easily handled. This is but a first and very imperfect solution of the problem, and suffices for the moment, but it does not command the future. Mr. Charles Tellier, now well known to your readers, has already long since proposed to supersede superheated water by liquid ammonia, which, under the same conditions of pressure, would give 200 kilogrammes of vapour, whereas water only gives 54, which will work at the usual surrounding temperature, and will not require jacketing to preserve its heat. A pressure of from 5 to 7 atmospheres suffices for ammonia, instead of 14 to 15 required by water; and 200 litres are sufficient instead of 1,000, and moreover the liquid does not betray its pressure by any exterior sign. The motor liquid will consequently occupy infinitely less space—will be less heavy, and more easy to control. There is no reason why omnibuses and carriages should not be constructed to carry their own motor, and to be able to move on or stop at the will of the conductor. Ammonia, as proposed by M. Charles Tellier for a motive power, possesses qualities so singularly appropriate for application to traction upon common roads or tramways, that if it were necessary to seek for a liquid fulfilling such conditions, it would be difficult to find anything better than the judicious employment of this body.

Vertical Boiler with Rapid Circulation.

The "Scientific American Journal" stated lately that one of the most curious characteristics of our time is that nearly all manufacturers who are obliged to employ steam are almost inevitably led to combine some new style of boiler. Consequently the number of these useful appliances multiply every day. I have already studied several hundreds, not to say thousands, but I must admit that none of them interested or struck me more than the present one, which I met with by chance in the workshop of a young boiler-maker of St. Denis, and whose first steps in the mechanical career I had encouraged. Roser's generator is composed of two enveloping parts, the outer one carry-

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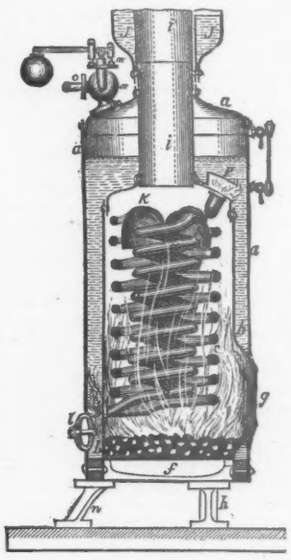
ing all the accessories, steam pipe, water level, &c., and the inner one containing the furnace with double or triple spiral tube, through which the water circulates, and which presents a very considerable heating surface. Around the chimney is a feed reservoir, the water contained in which utilizes the waste heat, which otherwise would escape up the chimney, together with the other products of combustion.

The advantages of this arrangement are manifest. The water circulates very rapidly; the tubes are always clear and free from incrustation, they require no cleaning, the metallic conductibility is always the same, and the economy of fuel is relatively enormous. In order to render this boiler as safe as possible, the connection between the spiral tubes and the inner cylinder are of fusible metal. In twenty minutes after lighting the fire, this generator is ready to supply steam at a pressure of from four to five atmospheres. All those who have employed this apparatus are quite astonished at the results it gives. I myself consider them so remarkable, that I beg leave to insert here a small drawing, together with a short explanation of the generator.



a. Exterior envelope of the generator.
b. Interior envelope, in which the concentric spirals *c* and *d* are situated, and through which the water circulates rapidly.
The joints connecting the spirals with the interior cylinder are of fusible metal.
f. Circular grate of the furnace.
g. Door of furnace.
h. Stand of the generator.
i. Chimney.
j. Reservoir to feed the boiler surrounding the chimney.
k. Break flame, which causes it to recurve and embrace all the spirals before it can escape.
l. Door for cleaning purposes.
m. Small spherical reservoir carrying the safety-valve and the steam pipe.

F. MOIGNO,
Canon of the Chapter of Saint Denis.

VIENNA, *September* 22, 1874.

THE International Sanitary Congress, held in this town, was closed last month by the president, Baron von Gagern. After a series of twenty meetings the delegates of nearly all civilized states have left Vienna, whither they had been sent by their respective governments for the purpose of helping to erect, on a scientific basis, and from their own practical experience, a bulwark against the disastrous scourges of mankind—epidemics.

The importance of this problem and the great interest which the whole world takes in its solution will justify me in giving a short review of the action of this congress and its practical results.

Let me confess at the outset, that the congress has not fulfilled the great expectations raised. But, at the same time, justice requires me to acknowledge that the consideration of this special subject is fraught with difficulties.

We hoped above all things that the congress would succeed in devising international measures and remedies by which it would be possible to prevent, with some degree of certainty, the outbreak and spread of epidemics, amongst which, first and foremost, must be named the cholera.

This our hope has been completely disappointed. It is true that the congress has recommended to the respective governments to establish quarantine, but only in certain cases. It is also true that the congress recommends the employment of disinfectant remedies, but only with timid saving clauses.

Now, both as regards the genesis and the development of epidemics, we fail to perceive the positive, the incontestable scientific basis underlying the measures advised.

Anyone who does not already know from the actions and proceedings of this international congress, may learn it by the unsettled and incoherent manner in which the respective resolutions are recommended to be employed, that the congress had not a clear unanimous idea, either about the first condition of all kind of prophylaxis, viz. about origins and characteristics of the sicknesses which are to be conquered, or about the efficacy of the remedies to be used in the different cases.

Whilst, for instance, by some members of the congress only certain district places have been regarded as central cholera-seats, it has been absolutely impossible to divert another section of the assembly from the opinion that the said contagion, under the influence of certain (though as yet undiscovered) circumstances, may arise everywhere.

Many of the delegates doubted the value of any kind of quarantine, whilst others amongst them clung with a determined tenacity to this mediæval institution.

The majority of the congress even acknowledged that there is not one remedy absolutely reliable; several minorities, on the contrary, pleaded very strongly first for lime-water, next for carbolic acid, then for iron vitriol, &c., to be employed as prophylactical remedies.

And it is owing to the absence of this positive scientific basis, that the resolutions here taken are as singular and even contradictory as those characterizing all cholera-congresses previously held.

It must be inconceivable to all practical men how it could be possible that the congress should adopt on the one hand the severest measures for quarantine on sea, and on the other hand abjure any sort of quarantine on land.

Surely it may be supposed that if the cholera can be avoided on the sea by quarantine, it can also be grappled with on shore. The cholera having been recognized as not being so dangerous, why do they propose such severe measures for sea-quarantine?

But the medal has not only this poor reverse; let us also look on its very gratifying obverse! All this disappointment would not have occurred had we not overstrained our attention. All modern sanitary science is still young, and wants before everything the experience drawn from the data gathered during the last few decades.

This fact has been fully acknowledged by the Vienna Cholera-Congress of this current year, and inasmuch as the recognition of a fault may be considered to be the first step to improvement, our cholera-congress, in full appreciation of the particular circumstances, has inaugurated a new era of this very important matter by passing the following resolution:—

"A permanent international commission is to be constituted in Vienna (as a central point between the West and the East) for the sole purpose of forwarding the practical study of the origin, character, and dissemination of epidemics by sending young and carefully-trained physicians as soon as possible to all places in the different countries where epidemics arise."

The labours of such an international commission, if directed in a systematical way in accordance with the same programme, will certainly offer to a future similar congress a much more practical foundation and more precious material wherewith to combat epidemics, than the congress just now closed had at its disposal.

The declared willingness of all governments to co-operate, makes the formation of this useful institution undoubted; and so the early existence of this international permanent commission is the only, but surely a highly valuable practical result of the four weeks' activity of the Vienna Cholera-Congress, 1874.

And for this important result we must all feel obliged to the honourable members of this congress.

Let us hope that this first step in the new, *in the practical* way, viz. the creation and the working of that international permanent commission, may be followed by the best further results.

E. LEONHARDT.